FLORISTIC AND ECOLOGICAL STUDIES ON THE LOW ALTITUDE GRASSLANDS OF THE COASTAL REGION OF THE WESTERN GHATS

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By

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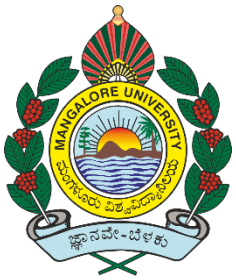

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DECLARATION

I Rashmi K, do hereby declare that the thesis entitled "FLORISTIC AND ECOLOGICAL STUDIES ON THE LOW ALTITUDE GRASSLANDS OF THE COASTAL REGION OF THE WESTERN GHATS"is a bonafide record of the research work, submitted by me, to the Mangalore University, Mangalagangothri, for the award of Doctor of Philosophy in Applied Botany. The work described in this thesis is original and has not been submitted, in any form, for a higher degree at any other University or Institution.

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Date:

Place: **Dr. Krishnakumar G.**

Dedicated to My Family

For their endless love, support and encouragement

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ABBREVIATIONS

ANOVA- Analysis of Variance

APG III-Angiosperm Phylogeny Group

GPS-Global Positioning System

IUCN-International Union for Conservation of Nature

PAST-Paleontological Statistics Software Package for Education and Data Analysis

PCA-Principal Component Analysis

NWG-Northern Western Ghats

NEG-northern Eastern Ghats

LRO-Low altitude rocky outcrops

RET-Rare Endangered Threatened

SL. No-Serial number

Jan. - January

Feb. - February

Mar. - March

Apr. - April

Jul. - July

Aug. - August

Sept. - September

Oct. - October

Nov.- November

Dec.- December

INTRODUCTION

I.1.1: Grassland ecosystem

Grassland is the most extensive terrestrial biome, occupying 41–56 × 106 km^2, or 31–43 percent of Earth's surface (White et al., 2000). Grasslands have been heavily used throughout human history, especially as a source of food for the livestock. Also, 39–90 percent of grassland has been converted to cropland or urban area, with only one hectare of grassland protected for every 10 hectares that have been lost. Grasslands are biologically rich and diverse, being dominated by the fourth largest plant family, the Poaceae. Ecologically, grassland is engrossing and possibly has been the subject of more ecological studies than any other system. Some of the important ecological concepts have emerged as a result of grassland research (Gibson,2009,2011).

Grasslands refer to vegetation community predominated by graminoids i.e., grasses and grass like plants. The major families found in the grasslands are Poaceae, Cyperaceae, Fabaceae and Asteraceae. The grasslands not only function as a major producer biome, but also serve as domain to a variety of micro and macro fauna. There are two different types of grassland ecosystems. They are tropical grasslands and temperate grasslands. Each of them has a specific climate that allows for an entirely different set of animal and plant life to live on it, but they are still both bordered by a forest and a desert while having soil that is ideal for cultivation and pasturing (Swarupanandan,1998).

The grasslands of the world are also under the threat of developmental activities and other land use changes resulting in habitat fragmentation, frequent fires and reduction in multifariousness. The Prairies of North America, Pampas of South America, the African Savannas, the Veldts of South Africa, the Caucasian Steppe, the Terai grasslands, the Alpine meadows of Himalaya and Shola grasslands of Western Ghats are some of the distinctive grasslands of the world. The grasslands globally have been classified into Tropical Savannas, Temperate grasslands and Steppes. The Savannas are characterized by large areas of grasslands with scattered trees found in the tropical region, whereas the temperate grasslands are extensive stretches of tall grasslands in the temperate regions, while the Steppes refer to extensive stretch of short grasslands found in arid and semi-arid temperate high-altitude regions.

Dhadabgao and Sankarnarayan (1973) in their book "The Grass Cover of India" had identified the following five broad types of grass cover found in India:2

1.*Sehima* - *Dichanthium* grasslands with an elevation range of 300-1200 m above mean sea level are found on the Deccan plateau, Chota Nagpur plateau, and Aravallis.

2.With a range of 150-300 metres above mean sea level, *Dichanthium* - *Cenchrus* - *Lasiurus* grasslands can be found in northern Gujarat, Rajasthan, the Aravalli hills, south-western Uttar Pradesh, Delhi, and Punjab.

3.*Phragmites* - *Saccharum* - *Imperata* grasslands are found in the Gangetic plains, the Brahmaputra Valley, and the Punjab plains, at elevations ranging from 300 to 500 metres above sea level.

4.*Themeda* - *Arundinella* grasslands can be found in the foothills and lower hills of Manipur, Assam, northern West Bengal, Uttarakhand, Himachal Pradesh, and Jammu and Kashmir, at elevations ranging from 350 to 2000 metres above sea level.

5.Above a height of 2000 metres above mean sea level, temperate - Alpine grasslands- spread across the Himalayan States and temperate high-altitude portions of Nagaland, Manipur, and the Western Ghats.

A detailed classification of Grassland ecosystem in India, has been given by Rawat and Adhikari (2015):

1.The Coastal Grasslands: Grasslands of the sea beaches: Mainland beaches, Island beaches, Salt marsh grasslands, Mangrove grasslands

2.The Riverine Alluvial Grasslands: Fertile river plains of the Indo-Gangetic plain, Brahmaputra plain and rivers

3.Montane grasslands: Himalayan Sub-tropical grasslands, Himalayan Temperate grasslands, Alpine meadows, Trans-Himalayan steppes, Grasslands of the North East Hills, Grasslands of Central Highlands. The Western Ghats: Plateaus of North Western Ghats, Shola grasslands, Southern Low land Plateaus and Eastern Ghats grasslands.

4.Sub-Himalayan Tall grasslands of Terai region: lowland region in northern India and southern Nepal that lies south of the outer foothills of the Himalayas, the Shivalik Hills, and north of the Indo-Gangetic Plain.

5.Tropical Savannas: Desert Savannas, Tropical savannas of Peninsular India, Northern Tropical Hill Savannas

6.Wet grasslands: Semi-aquatic species of grasses dominate these grasslands. For example, the Phumdi grassland of Manipur.

Grassland ecosystems dominated by graminoids (i.e., grasses and sedges) that perform ecological functions including the maintenance of biodiversity (Tyagi et al., 2010). Grasses are the fourth largest group of flowering plants, globally represented by 10,550 species under 715 genera (Pathak, 2013). In India there are 240 genera and 1,200 species which shows a highly valuable grass diversity (Parmar et al., 2012).
Western Ghats is listed as one of the 35 'biodiversity hotspots' of the world (Anon., 2005,2007). Nearly 1600 endemics are reported from various parts of Western Ghats (Nayar,1996). The high-altitude montane grasslands/plateaus and low altitude grassland plateaus also contributes endemic diversity (nearly 27%) in the Western Ghats (Joshi & Janarthanam 2004; Nagendra and Utkarsh, 2003; Rao et al., 2012).

The shola forest-grassland is the tropical montane forest found in the upper reaches of India's Western Ghats. This mosaic ecosystem is native only to the southern Western Ghats and found in the high-altitude mountains of Kerala, Tamil Nadu and Karnataka. These grasslands (above 1800 m) are home for *Imperata cylindrica*, *Arundinella setosa*, *Chrysopogon hackelii*, *Eulalia trispicata*, *Themeda triandra* and *Jansenella griffithiana*. Angiospermic herbs and shrubs like *Hypericum japonicum*, *Osbeckia leschenaultiana*, *Gaultheria fragrantissima*, *Phlebophyllum kunthianus*, *Anaphalis aristata*, *Strobilanthes kunthianus*, *Rumex nepalensis*, *Exacum bicolor*, *Lilium neilgherrense*, *Lobelia nicotianaefolia*, *Polygala siberica*, *Striga asiatica*, *Walhenbergia gracilis*, *Crotalaria notonii*, *Knoxia mollis*, *Indigofera pedicellata* and several Acanthaceae and Lamiaceae members.
High altitude grassland plateaus are (above 800 m) mainly concentrated in the form of a common geomorphological feature in the northern Western Ghats, particularly in the districts of southwestern Maharashtra (Lekhak and Yadav,2012). *Dimeria*, *Ischaemum*, *Manisuris*, *Arthraxon*, *Heteropogon*, *Arundinella*, and *Jansnella* along with several other herbaceous plants belonging to Gentianaceae, Fabaceae, Asteraceae, Melastomataceae, Scrophulariaceae and Lamiaceae dominate these grasslands.
The low altitude grassland plateau (below 100m) lies between Konkan-Malabar region (Raychaudhuri,1981). A laterite mixed low elevattion grassland plateau can be considered as an amphibious ecosystem. The alternation of the wet and dry conditions creates an unusual ecological situation that supports unique biota. For example,

Lepidagathis keralensis, *Lepidagathis clavata*, *Justicia ekakuasuma*, *Rotala malabarica*, *Eriocaulon gopalakrishnanum*, *Eriocaulon madayiparense*, *Lindernia tamilnadensis*, *Parasopubia hofmanni* are few such notable endemics that survive in such an ecosystem where they can tolerate a wide range of conditions. The monsoons here, notably provide a conducive environment for many such species to complete the life cycle and these plants are 'narrow endemics' that they are unable to survive anywhere outside this environment (Watve,2013).

Important aspects of low land plateaus with respect to medicinal plants, microhabitats and narrow endemics are discussed by various researchers (Madhu et al.,2013; Sreejith et al.,2016; Pramod and Pradeep, 2021). The increase in the intensity of land use has resulted in several threats to the biodiversity of the Western Ghats (Pramod et al., 1997; Karunakaran et al.,1998).

1.1.2: AIMS

The goal of this study was to characterise floristic composition and to emphasise the importance of grassland plateaus in low-elevation areas. A foundation of scientific knowledge on the ecological relevance of low altitude grassland plateau is required to develop conservation and management strategies for this terrain, particularly at a time when habitat destruction is at an all-time high.

1.1.3: OBJECTIVES

I. Floristic studies on the low-altitude grassland.

II. To record rare, threatened and endemic species.

III. Quantitative and qualitative ecological studies on plant diversity to evaluate the importance of grassland for habitat conservation.

IV. To study the phenology and seasonal succession of the flora of these grasslands.

REVIEW OF LITERATURE

1.2: Review of literature

1.2.1: Studies on high altitude shola and montane grasslands

The floristic studies of the Shola are very scanty or limited data available from the earlier floristic investigations viz., Wight (1835-1853) Icones Plantarum Indiae Orientalis, Hooker's (1872-1897) Flora of British India, Gamble (1915-1936) Flora of the Presidency of Madras and other regional and local Floras. At first, Fyson (1932) has studied floristic account on the shola forests of South Indian hill stations. Due to the influence of fire and grazing these grasslands forms secondary serial stages which may be very stable pre-climax. The grassland associations and successional study and the results revealed the climatic climaxes, major associations, ecological factors of the soil which manages plant associations and the factor which brings succession (Bharucha and Shankaranarayan, 1958).

Ecology of a montane grassland on five hill sides in Sri Lanka was investigated by Pemadasa and Amarasinghe (1982). They used association analysis and reciprocal averaging ordination for this investigation. They found that vegetational and environmental diversity within the grassland is considerable but in different hillsides diversity was distinct and primarily depends on the elevation, altitude, climate, soil and degree of human interference.

Saravanan et al. (2014) investigated the impact of forest fire on the floral diversity of a degraded shola-grassland ecosystem. The fire changed the chemical, biological, and physical qualities of the soil, as well as the vegetation pattern. Using the quadrat approach, the effect of fire on the plant diversity of the land was evaluated in different intervals following the fire and after the monsoon.

1.2.2: Population biology studies

Studies on population of grassland using quadrat method has been done by various researchers (Solbrig et al., 1980; Fenner,1998; Wang et al., 2002).

Quantification of grass cover and species composition of herbaceous plant and weed abundance was studied in grasslands of Corbett Tiger Reserve by laying 50 × 50 cm quadrats (Rawat et al., 1997;2000). They observed that the highest numbers of species

were found in forest grassland edge followed by degraded lands. Parmar et al., (2012) assembled 286 species of grasses form different parts of India. Rao et al., (2012) explored the grasses of Anshi National Park. They reported 116 flowering plant species belonging to 109 genera and 36 families. They found that Poaceae was the dominant family followed by Scrophulariaceae and Asteraceae.

Bhat and Ghate (2000) studied on herb species diversity of the Western Ghats of Karnataka in different forests. Herb species diversity was assessed by samplings from nine different vegetation types (both manmade and natural). They enumerated all herb species and individuals using line transact method. They found a higher species richness in the semi- evergreen forest and was lowest in deciduous forest.

1.2.3: Floristic composition in grassland plateaus

Floristic studies in lateritic plateaus have reported the occurrence of many endemic species and habitat-specific flora (Bachulkar 1983; Gaikwad,2002;2004; Watve 2013; Rahangdale & Rahangdale 2014) throughout the Western Ghats, India. As opined by Joshi & Janarthanam (2004) recent critical studies on these plateaus have added many new species from these plateaus. Extensive field studies and fascinating discoveries done by (Salunke & Potdar, 2004; Malpure & Yadav, 2009; Yadav et al.,1998, 2008; Yadav and Lekhak,2009), indicate the sheer need of floristic studies on plateaus in northern Western Ghats. The plateaus are very species rich, for example, the Durgawadi Plateau in Maharashtra of three-square kilometre area has more than 600 angiosperm taxa of which 150 are endemic and 105 faunal members (Rahangdale & Rahangdale, 2014), which indicates the extent of species richness on the isolated hillocks or plateaus in the Western Ghats.

The flora of Manilal and Sivarajan (1982) is the first detailed attempt to explore low altitude grasslands. The flora of similar habitats of Kasaragod has been explored by Ansari (1985). Babu (1990) has studied the flowering plants diversity on low altitude elevations of Malappuram districts. A detailed expedition on bladderworts by Janarthanam and Henry (1992) revealed the occurrence of nearly 15 *Utricularia* spp in low altitude plateaus. Ansari and Balakrishnan (1994,2009) explored diversity of *Eriocaulon'*s and accounted 65 species for India, in which nearly 25 species are confined to low altitude plateau region. Exploration by Joseph and Sivarajan (1990), Pradeep et al., (1990;1991;2003;2013), Madhusoodanan and Singh (1992); Shahina

and Nampy (2015) have given deeper insight about floristic diversity of grassland plateaus.

Some of the new species and vareities discovered from low altitude plateaus in the recent years include *Rotala malabarica* (Pradeep et al., 1990), *Nymphoides krishnakesara* (Joseph & Sivarajan, 1990), *Justicia ekakusuma* (Pradeep & Sivarajan, 1991), *Lepidagathis keralensis* (Madhusoodanan & Singh, 1992), *Eriocaulon sivarajanii* (Ansari and Balakrishnan,2009), *Eriocaulon ansarii* (Pradeep and Sunil, 2003), *Eriocaulon malabaricum* (Pradeep and Nampy,2011), *Rotala tulunadensis* (Prasad et al.,2012), *Eriocaulon cheemenianum* (Biju et al., 2012), *Eriocaulon gopalakrishnanum* (Rashmi and Krishnakumar,2012), *Lindernia madayiparense* (Ratheesh Narayanan et al.,2012), *Coelachne madayensis* (Pramod and Pradeep,2012), *Eriocaulon madayiparense* (Swapna et al.,2012), *Rotala khaliana* (Sunil et al.,2013), *Parasopubia hofmannii* (Pradeep &Pramod,2013), *Eriocaulon kannurense* (Sunil et al.,2013), *Blyxa mangalensis* (Rashmi and Krishnakumar,2016), *Blyxa kasaragodensis* (Biju,2016), *Reissantia sessiliflora* (Navendu et al., 2017), *Nymphoides krishnakesara* var. *bispinosa* (Biju et al.,2017), *Nanooravia kayyurense* (Shaju et al.,2017), *Polycarpaea rangaiahiana (Geethakumari et al.,2019), Rotala baileyana* (Rogimon Thomas et al.,2019), *Eriocaulon lanceolatum* var.*bhatkalense* (Rashmi and Krishnakumar, 2020). etc., emphasize about the rich diversity in the grassland plateaus. These studies highlight the importance of grassland ecosystems in terms of floral diversity and species richness.

1.2.4: **Endemism**

Western Ghats harbours around 1,600 endemic plant species, which are documented by many workers Nayar (1996). Though many endemic and new species have been reported from the lateritic hills and grassland plateaus, floral inventory of these ecosystem are limited (Jayarajan 2004; Sreejith et al. 2020). Number of endemic taxa and species richness varies in each plateau (Thorpe et al., 2018; Lekhak and Yadav,2012; Rao et al., 2012; Rhangdale & Rahangdale,2014). Rahangdale & Rahangdale (2014), stated that, the species composition even in nearly similar plateaus varies considerably.

According to Rahangdale & Rahangdale (2014); Irwin & Narasimhan (2011) in their review of endemic genera of angiosperms in India also mentioned that Poaceae exhibit highest generic endemism owing to its earlier stages in evolution and dynamism. In this study, 49 genera have been considered as endemic to India. Out of which 36 are specific to central Peninsular India. According to Lekhak and Yadav, (2012) among the species recorded from the plateaus studied, 67 are endemic to Western Ghats, of which, 39 species (58%) are confined to plateaus of the study area. Maximum number of endemics (41) was reported from Kas (Satara) while the lowest count (6) was recorded from Barki (Kolhapur) and Chalkewadi (Satara). The family Poaceae has largest number of endemic species (22 species), followed by Fabaceae with 5 species and Apiaceae, Apocynaceae and Asteraceae with 4 species each. Also, angiosperm diversity of Kas reservoir from Maharashtra was explored by Pawar and Sonawane (2012). They observed 94 plant families and assessed that dicot families dominate over monocotyledons. Bhattarai et al., (2012) studied the endemic plant diversity on the Kas plateau of Western Ghats. They divided the plateau into two types viz., mesoscale and microscale distributions, where they recorded the major ecological zones and seasonal habitat defined by hydrogeomorphic content. They also found that 100 phytogeographically significant plant species on the plateau top, comprised in 43 genera from 26 families. Watve (2013) reported 188 endemic taxa from NWG and Konkan region of Maharashtra. Similar pattern was obtained by Joshi & Janarthanam (2004) in their study on endemics of Goa region.

Rao et al., (2012), have observed differences between species composition of different plateaus in Uttara Kannada district, Karnataka. The study was mainly focussed on the seasonal herbal flora of Ankola Taluk in the north through Kumta, Honnavar and to the Bhatkal taluk in the south. They have reported several notable endemic herbs such as *Eriocaulon fysonii, E. lanceolatum, E. cuspidatum, Rotala malampuzhensis*, rare grasses like *Danthonidium gammiei* and threatened endemic hydrophyte *Wiesneria triandra*, and many more interesting species. Drought enduring species like *Ceropegia* spp., *Euphorbia acaulis*, *Curculigo orchioides*, *Theriophonum dalzelli* are reported.

In a recent expedition by Pramod and Pradeep (2021), out of the 636 flowering plant taxa recorded from the microhabitats of the Madayipara plateau, 120 species comes

under RET section as per IUCN criteria 3. Seven species, viz., *Dimeria hohenackeri*, *Limnopoa meeboldii*, *Syzygium caryophyllatum*, *Hopea ponga*, *Lindernia manilaliana*, *Utricularia cecilii* and *Nymphoides krishnakesara* were endangered. The species *Eriocaulon kolhapurense*, *Pterocarpus marsupium*, *Santalum album* and *Ixora malabarica* were vulnerable. The species *Isachne veldkampii* and *Rotala malabarica* were Critically Endangered and the species *Nothopegia heyneana* was Nearly Threatened. The conservation status of the majority of the plateau's endemic species, many of which are narrow endemics, has yet to be assessed.

Because of the remarkable topographical elements, laterite rich grasslands harbour various herbaceous endemic taxa (Baskin and Baskin, 1988). Irwin and Narasimhan (2011) reviewed the endemic genera of angiosperms in India. Peninsular India is home to a large number of endemic genera. Only 49 genera are native to India, according to their findings. Herbaceous genera account for 71% of the genera, with a higher prevalence in moist evergreen forests and grasslands. They have advised that a conservation system based on existing IUCN standards be implemented immediately.
Wagh and Auti (2019) documented endemic flowering plants of Rajerwadi basaltic outcrop, Chandwad district, Nasik, reported 57 endemic species belonging to 35 families. Shreejith et al.,2020 recorded 364 genera with 535 species, of which 334 are native and 201 are non-native.

1.2.5: Inselbergs

The granitic and gneissic outcrops are known as inselbergs in Africa and South America (Barthlott & Porembski, 2000). Grasslands cover broad areas of both temperate and tropical regions, but they occur principally in climatic zones with a pronounced dry season (Axelrod, 1985). Plateaus in northern Western Ghats lack proper substrate (soil) and exhibit extreme climatic conditions. Their environment usually shares a series of difficult characteristics, such as high UV exposure, daily thermal variation, constant winds, high evapotranspiration, low water retention and impermeable soils (Porembski et al., 1994; Scarano, 2002). Krieger et al., (2003) have worked on species turnover of ephemeral plant communities in nearly 200 seasonal rock pools in Ivorian inselbergs. Here species turnover increased with soil depth and area and climatic influences were negligible on the community dynamics. According

to Heilmeir et al., (2004), the landscape matrix is known for harsh environmental circumstances such as quick desiccation, rehydration, and nutrient deficiency. Therefore, seasonal plants on these grasslands are characterised by morphological and biochemical changes.

Plant communities here are basically edaphically controlled and show adaptation for water accumulation, such as succulence and poikilohydry, carnivory in response to the lack of nutrients (N, P and S) in the soil and the presence of subterranean organs (bulbs, corms, tubers and rhizomes) to overcome extreme temperature during summer (Watve,2003a;2003b; Porembski & Watve,2005 and Watve & Thakur, 2006). Muller (2007) and Jacobi (2007) have concluded that herbaceous vegetation of seasonally wet habitats on inselbergs and laterite crusts vary significantly. Therefore, a slight variation in the ecological situations can result in variety of plant communities.

1.2.6: Rock outcrops

Lateritic plateaus are also known as rock outcrops, which are ecosystems in which parts of freely exposed bedrock rise above the soil surface due to natural causes. (Watve, 2003;2009).

The word ‘laterite’ (from Latin letter meaning brick) was first given by Buchanan in 1810 to a clay rock, hardening on exposure, observed in Malabar. As early as, Buchnan (1807) coined the term laterite for hardened clay called "lttica kallu" (in vernacular Malayalam, meaning Brick - stone) occurring in Angadipuram (Malappuram district, Kerala) that is used as a building material in the northern districts (Malabar) of Kerala.

Laterite soils are often deficient in fertility and are unsuitable for crop production due to extensive leaching and low base exchange capacity. These, however, are excellent for growing plantation crops when manured and irrigated. These soils support grazing grounds and woodlands in some regions. Laterite and lateritic soils are special in that they can be used to make important building materials. These soils can be easily cut with a spade otherwise, but it hardens like iron when exposed to air. That is because it is the end- product of weathering and is indefinitely durable (Berges and Beadle (1953).

According to Polynov (1951), laterite soils may be “the end products of weathering given sufficiently long time”. According to Prescot and Pendleton (1952), it is formed

by the oxidation and precipitation of iron. Berges and Beadle (1953) suggest the formations as a result of the accumulation of iron oxide by way of deposition from highland waters. According to Thomas et al., (1993), the plateaus are exposures of a laterite horizon and resultant of the top soil loss due to erosion. Based on the above observations, Watve (2013) has extensively studied the rocky plateaus of Maharashtra in the coastal region.

1.2.7: Phytogeographic affinities

Geomorphological features like lateritic plateaus in the study region occur over a vast geographic range. They are quite common in Africa and South America and are known as inselbergs (Porembski et al.,2000). Lateritic plateaus resemble African inselbergs in terms of life-form composition. Both represent therophytes as the predominant life-forms. However, phanerophytes dominate the American inselbergs. In addition, the African outcrops are granitic while lateritic plateaus in South Western Ghats are made up of basalt (Porembski, & Barthlott,2000 a, 2000b).

Some genera like *Burmannia*, *Ceropoegia*, *Cyanotis*, *Dipcadi*, *Drosera*, *Fimbristylis*, *Lindernia*, *Rhamphicarpa*, *Rotala* are common in African outcrops (Watve, 2003b). However, in overall floristic composition these are very different. Lateritic plateaus are dominated by Poaceae, Orchidaceae, Asteraceae and Fabaceae in the Northern altitude grasslands of Western Ghats. Their counterparts in Africa are recognized by high percentage of Fabaceae, Scrophulariaceae and Lentibulariaceae. while in South America Melastomataceae, Orchidaceae, Cactaceae and Bromeliaceae dominate (Porembski and Watve,2005).

1.2.8: Microhabitats

Microhabitats are defined as “islands upon islands”, i.e. plants on the plateaus are adapted to various microhabitats and each of these microhabitats is unique in its edaphic properties, water availability and species composition (Ornduff,1987; Porembski et al.,2000). Microhabitat classifications are done by few earlier researchers (Porembski et al., 1997; 2000; Seine et al., 1998; Jacobi et al., 2007). A detailed account of microhabitat categorization for rock outcrops is already available

by (Porembski & Barthlott, 2000; Jacobi et al., 2007; Lekhak &Yadav,2012; Watve, 2013; Rahangdale & Rahangdale, 2014). Plant species commonly seen in the microhabitats have been described by Watve (2003, 2009), Watve and Thakur (2006) and Lekhak & Yadav (2012).

Laterite plateaus have microhabitats with distinct species assemblages, and plant distribution is influenced by microclimate and edaphic factors. They show high species richness and diversity (Watve, 2013). Hence, some plants grow in similar kind of microhabitats and few species grow in specific kind of microhabitats (Watve, 2013; Sreejith et al.,2016).

Lekhak and Yadav (2012) have reported microhabitats like Boulders (B), Crust Edges or Cliffs (C), Ephemeral Flush Vegetation (EFV), Rock Crevices/Fissures (RC), Seasonal Ponds (SP), Small Ephemeral Pools (SEP), Soil-covered Areas (SCA), Soil-filled Depressions (SFD), Soil-rich Areas (SRA), Tree Cover and Tree Associated (T) from high elevated Kas plateau in Maharashtra.

Watve (2013) also documented microhabitat types like Cryptogamic vegetation of rock surfaces (R), Cryptogamic vegetation of boulders (B), Vegetation of rock crevices (CR), Vegetation of depressions, Vegetation of water pools, Ephemeral or Seasonal Rock Pools (SRP), Shallow rock pools, Deep rock pools, Vegetation of Ponds, Vegetation of drainage channels (DR), from rocky plateaus in the northern Western Ghats and Konkan region of Maharashtra, India with recommendations for conservation and management.

Rahangdale & Rahangdale (2014) observed that some microhabitats in particular season are dominated by Poaceae, Asteraceae and Anthericaceae in post monsoon season. They have also stated that even closely located plateaus differ in types of microhabitats, which ultimately defines the diversity of plateaus.

The most common Microhabitat types on the low elevation lateritic hillock plateaus of northern Kerala have been described along with characteristic species assemblages by Sreejith et al., (2016). Ephemeral flush vegetation, Rock crevices/fissures, Small Ephemeral Pools (SEP), Soil-Filled Depressions (SFD), Soil-Rich Areas (SRA), Tree Cover and Tree Associated (TCTA), Boulders (B), Crust Edges or Cliffs (CEC) are reported from low elevation lateritic grasslands of Kerala. This study analysed these communities for their similarity in species composition, species index and species

richness. According to this study, alteration of very wet and dry condition creates an unusual ecological situation and varying microhabitats that supports unique biota. Plants on the plateaus are adapted to various microhabitats and each of these microhabitats is unique in its edaphic properties, water availability and species composition. This detailed study was carried out in Madayipara, Kerala, and they have identified total of nine microhabitats and analysed the distribution of herbaceous plants. Out of 263 species recorded, 194 species were specific to particular microhabitats and the remaining species grew in multiple microhabitats.

According to Thorpe et al., (2018) microhabitats on a plateau define its quality and are a result of macroclimate, edaphic processes, and anthropogenic activities. The occurrence of taxa and the seasonal succession pattern in each microhabitat varies significantly depending on soil topography, moisture content, rain fall intensity, plateau formations, and a variety of other ecological/geographical factors. The most common habitat types observed on plateaus are described by these authors and are based on fairly established categorization for rock outcrops by Porembski & Barthlott (2000) and Jacobi et al., (2007) with some modifications.

However, microhabitat classifications are limited by the fact that on the rocky plateaus there is no clear physical demarcation between the habitats. An appropriate classification specifically for rocky plateaus could be possible only after detailed ecological studies from different parts of India.

1.2.9: Seasonal variation in herbaceous plants

Seasonal succession of grassland plants has received very little attention. Weaver and Bruner (1945) determined the course of succession in an old native pasture under complete protection from grazing. In this study nature and rate of regeneration of the vegetation in its return toward the grassland climax have been ascertained and the changes in the population was fully recorded. Secondary succession after cultivation has been intensively studied in the tallgrass prairie of Oklahoma (Weaver and Bruner, 1945; Booth, 1941; Penfound & Rice,1957a; Risser & Rice, 1971; Kaputska & Moleski, 1976; Collins and Adams,1983). Quadrat and seasonal succession studies revealed the complex diversity pattern variations depending on pre monsoon to post monsoon seasons. The growing season starts with dominance of ephemerals and then

later this is replaced by perennials. Both, the number of species and number of individuals declines after a peak at the beginning of the growing season (Biswell et al., 1956; Isichei & Longe, 1984; Joshi and Janarthanam, 2004; Hanif et al., 2007). Burbanck and Platt (1964) evaluated the granite outcrops in South-eastern United states, where they found 76 species of plants from 40 islands. The flora of those groups was distinct from that of the surrounding area. During weekly intervals, the pattern of seasonal succession in a tiny isolated rock ground in Nigeria was observed, and species were estimated by counting all individuals. During the initiation, Island was covered by ephemeral plant species, later it was replaced by perennials (Isichei and Longe, 1984).

Singh and Yadav (1974) studied the variation in composition, plant biomass and net productivity in tropical grassland at Kurukshetra. The phytosociological values of the species were studied in monthly intervals. According to this study, the majority of the species were found to be spread evenly. Different species predominate in different months and seasons. The above-ground mass net productivity was determined to be highest during the wet season and lowest during the winter season.

Lekhak and Yadav (2012) have given a small account on succession of monsoon flora in Kas plateau. The first being the pre monsoon phase (June – July) is characterized by the growth of grasses on the plateaus. In the monsoon phase (August – September) mainly geophytes such as *Curculigo orchioides*, *Dipcadi ursulae*, *Eriocaulon tuberiferum*, *Flemingia nilgiriensis*, *Habenaria grandifloriformis*, *Hypoxis aurea*, *Iphigenia stellata*, *Murdannia lanuginosa* come in flowering. This is the peak flowering period on the plateaus. In the post monsoon phase (October – December) Poaceae members come in flowering. The fourth phase (January – May) is the dry summer during which only a few species such as *Blumea eriantha*, *Blumea malcolmii*, *Crinum pratense*, *Drimia polyantha*, *Lepidagathis cuspidata*, *L. prostrata* and *Pancratium triflorum* were recorded.

Based on the phenology of the plants successional phases can be recognized (Lekhak and Yadav,2012). However, few observations on phenological trends have been made out by Opler et al., 1980; Watve (2007); Nakar and Jadeja,2015; Sreejith et al., (2016), Rahangdale and Rahangdale (2014). These patterns of occurrence and their phenology (frequency, duration and time) in the community is influenced directly or indirectly by climatic factors like photoperiod, temperature, humidity and

rainfall/precipitation (Opler et al., 1980; Van Schaik et al., 1993; Appaji et al.,2014; Bawa et al., 2003). Based on climatic conditions most of the researchers have identified four phases of seasonal succession in plant communities (Collins and Adams,1983; Lekhak and Yadav,2012).

Ramesh & Pascal (1991) observed that the length of the dry season plays an important role in the distribution of species along the Western Ghats and not the amount of rainfall. The flowering of the endemic herbaceous species starts in June with the availability of moisture and reaches its peak in the month of September when there is enough moisture in the soil. It shows a steady decrease in flowering with the reduction in soil moisture. The phenological patterns shown by the herbaceous endemics is in accordance with the general flowering pattern of the herbs observed by Shivaraj & Krishnamurthy (1989) along the Shevary hills in the Eastern Ghats and Braganza (1998) on the plateaus of Goa. These studies have shown that phenology of herbaceous flora in the plateaus is mostly controlled by rainfall pattern in addition to other environmental factors.

Martinkova et al., (2000) described the changes in the phenological patterns of grassland species in relation to the ecological and morphological traits.

Effect of temperature and precipitation on advanced flowering phenology in semi-arid grassland was evaluated by Lessica and Kittelson (2010). They collected first flowering data for herbaceous broad-leaved species from 1995 to 2008 along an existing permanent transect. The results revealed that flowering phenology may be changing faster and precipitation play a more important role in semi-arid grasslands than humid temperate system. Nakar and Jadeja (2015) invented on phenology of 26 species of 13 different botanical families in Girnar Reserve Forest near Junagadh, Gujarat, India, for the reproductive phenological events, viz. flowering and fruiting from August 2008 to August 2011. Timing of fruiting phenology is also well studied in connection with different abiotic factors, but the relationship with temperature and rainfall has been given attention.

STUDY AREA AND METHODS

2.1.1: Physiography

The coastal belt: The Western Ghats run in a north–south direction in the east and to the west is the Arabian Sea. The area forms a part of the north Western Ghats. The entire study zone can be divided in to three main physiographic units: (1) hills and valleys along the Ghat zone, (2) a narrow coast line and (3) a mainland with plateaus between the hills and the coast. Behind the coastal alluvium and sand deposits, running closely parallel to the sea are flat topped hills and plateaus of laterite, their heights ranging from 60 to 100 meters. Behind the hills are ridges and the peaks of Sahyadri's, the real Western Ghats ranges. The rivers flowing west through deep valleys of mountains and in between lateritic hills towards the coast form estuaries and backwaters before joining the Arabian Sea.

2.1.2: Study area

The present investigation has been undertaken to study diversity, distribution, endemism, population dynamics, microhabitats and status of seasonal variation, successional and phenological pattern of herbaceous species in low altitude grasslands. The size of the studied plateaus varied from 0.2 km^2 to 4.25 km^2. The materials and methodologies adopted in the present study are detailed here under.

Description of the study area:

Uttara Kannada region (Bhatkal)

Bhatkal (13.99915°N and long. 74.55929°E) in the Uttar Kannada district of Karnataka has an average elevation of 4 metres (13 ft) above mean sea level. Bhatkal plateau is the richest laterite floristic province of Uttara Kannada district which covers 425 ha of area, therefore worth of its floristic and ecological studies.

Dakshina Kannada region

Dakshina Kannada (lat. 12.8438° N and long. 75.2479° E) has an average elevation of 30 metres above mean sea level. The topography of the region consists of a plain that runs up to 30 km (18.64 m) from the shore and undulating, hilly terrain in the Western Ghats to the east. The primary rivers that flow into the Arabian Sea are the Netravathi, Kumaradhara, Gurupura (Phalguni), Shambhavi, Nandini or Pavanje, and Payaswini.

Kasaragod region

Kasaragod district (lat.12.4996° N and long. 74.9869°) has an average elevation of 19 metres above mean sea level. This area is on the estuary where the Chandragiri River empties into the Arabian Sea, which is also the district's longest river.

Kannur region (Madayipara)

Madayippara, a good representative of the southern Indian midland lateritic plateaus, is located in Madayi Panchayath, near Payangadi Town in Kannur District of Kerala, southern India. The plateau covers an area of 3.65km^2, between 12.01–12.05 ^{0}N and 75.23–75.27 ^{0}E, at an altitude of about 50m from the mean sea level.

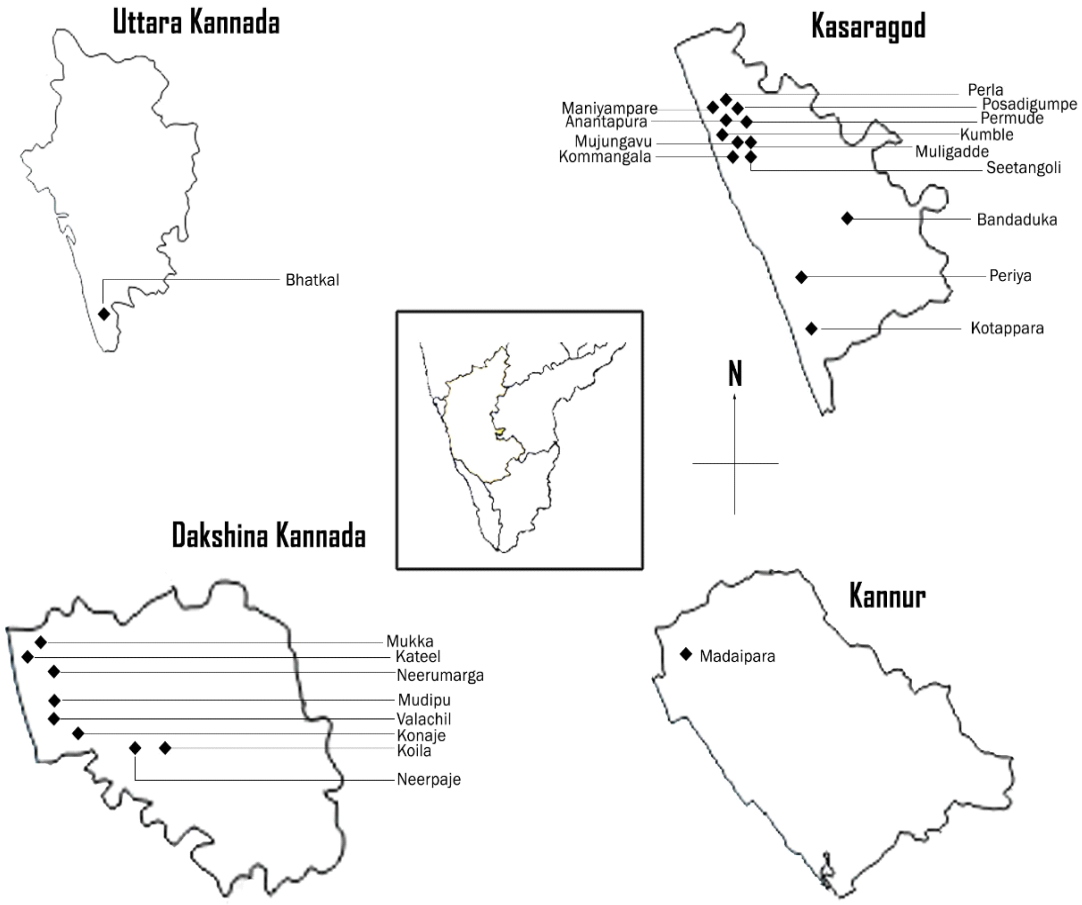


Figure 2.1: Location map of study areas.

2.1.3: Geology and Soil

The area's numerous rock formations are all part of the old Archean complex. In addition, there are deposits that can be categorised as recent, sub-recent, or lateritic. Laterite-like formations cover much of the shore and a small portion of the interior. These rocks have a substantial thickness to them. Clays and shell-limestone deposits are quite new. Red soil and laterite soil near to coastal sands are the most common soil types in the study area. The high iron and aluminium concentration in red soils distinguishes them. They have a pH of 6-8, a low base-status, and little organic stuff. Laterite soils have a vesicular structure and are typically reddish or yellowish-red in colour.

2.1.4: Climate

The climatic conditions vary from hot dry to warm humid in different seasons, viz., pre-monsoon (March–May), monsoon (June–November), and post-monsoon (December–February).

Summer: The summer season starts from March and extends till May. April and May are the hottest months in Karnataka and Kerala. During these two months the weather turns very dry and uncomfortable in the states.

Monsoon: The southwest monsoon wind brings rain by the first week of June with an average rainfall of 3500 mm (Table 2.1). The highest rainfall occurs between June and July and the monsoon begins to withdraw by September. The post-monsoon season begins from October and continues until December. This period brings a considerable stretch of dry period between November and May.

Study Region	2010	2011	2012	2013	2014	2015	2016	2017
Dakshina Kannada	3394.08	3915.5	3254.2	2751.3	2919.9	3167.02	2849.05	2932.05
Bhatkal	3467.09	4011.2	3321.5	3391.2	3911.3	3123.1	3234.5	3211.5

Kasaragod	3334.08	3715.5	3054.2	2751.1	2519.9	3127.02	2949.05	3245.05
Kannur	3677.09	4071.2	3041.9	3391.9	3811.3	3123.1	3934.9	3200.1

Table 2.1: Rainfall data of different study regions.

Winter: The winter season extends from January to February. These are the coldest months in most parts of Karnataka and Kerala and the temperature dips low. The weather remains pleasant as the humidity reduces considerably.

Temperature: The average temperature ranges between 21°C and 30° C (Figure 2.2). The temperature rises from March to May and the maximum temperature rises up to 36° C. The days are very hot at 32°C and the nights are cool at 18°C during November and December.

Humidity: Due to the proximity of the sea, the study area is humid, with humidity level ranging from 70% to 95% in monsoons (Figure 2.2). From July to September the heat reduces to an extent due to the rainfall but the humidity stays high.

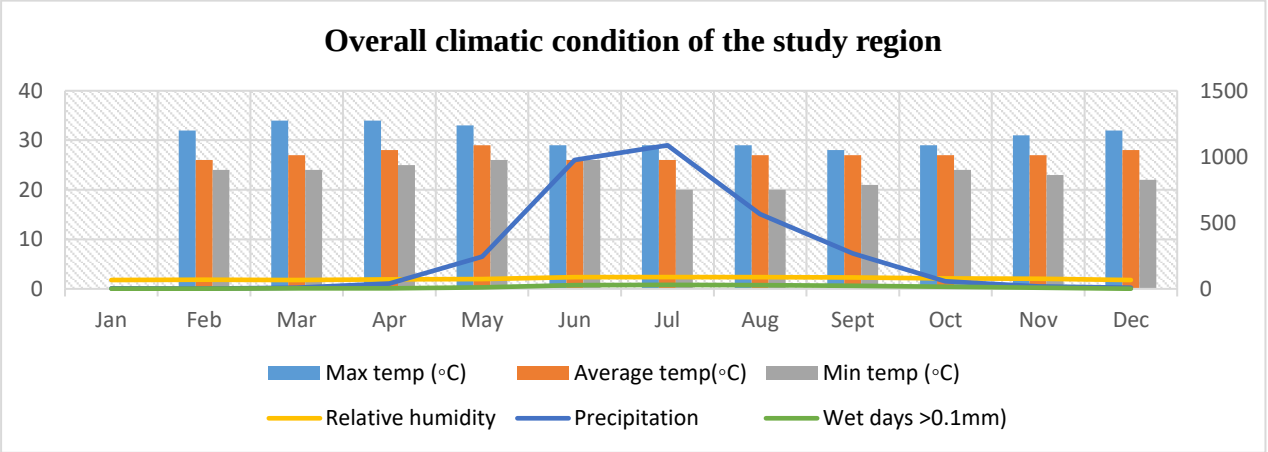


Figure 2.2: Average Temperature and Humidity in the study regions.

2.1.5: Vegetation types in study area

Vegetation along the Coastal belt: Coastal and Mangrove vegetation is common in small back water streams along with dense growth of mangrove fern. Beyond this deciduous forest with evergreen and deciduous species are seen. Whereas, grasslands support growth of herbaceous plants along with shrubs and trees.

Forest plantations: Monoculture forest plantations have been raised in the forest for more than a century. Cashew plantations are common in interior hillock regions of

Kasaragod and Dakshina Kannada district. *Acacia* plantations are widespread in study regions to meet raising timber needs.

2.2: Methodology

2.2.1 Field work

Field work days are categorized into - Pre-monsoon phase (May), Monsoon phase (June-September) and Post Monsoon phase (October-November), Cold & dry phase (December-April). Since heavy monsoon period support maximum growth of grassland therophytes, July and September were ideal months for 90% of the collection. Konaje plateau was selected exclusively for phenology and succession studies. The data on latitude and longitude thus obtained was calibrated with Google Earth 6.2 (http://www.google.com/earth/ index.html). Each plateau was GPS marked. Regular field works were conducted during different seasons: between 2011 and 2016 to study floristic richness in various study locations. Study locations are represented in Figure 2.1. Details of field visit date and other details are given in Table 3.2. Relevant photographs for the studies are given in (Plate. 1-47).

Region	Study localities	Taluk	Lat	Long	Elevation (m)	Threat	Disturbance
Uttara Kannada region	*Bhatkal (BT)	Bhatkal	14.0186 N	74.56985 E	95	Proposed land for housing colonies, *Acacia* plantation, Grazing	Moderate
Dakshina Kannada region	Mukka-Surathkal (MS)	Mangalore	12.4387° N	75.2012° E	22	Infrastructure	High
	Kateel (KT)	Mangalore	12.4387° N	75.2012° E	22	Grazing	Low
	*Neerumarga (NM)	Mangalore	12.4387° N	75.2012° E	22	Infrastructure	High
	*Valachil (VL)	Bantwal	12.8751° N	74.9428° E	22	Infrastructure, Mining	High
	*Konaje (KJ)	Mangalore	12.8170° N	74.9231° E	22	Infrastructure	High
	Mudipu (MP)	Bantwal	12.8029° N	74.9642° E	22	Infrastructure	High
	Neerpaaje (NP)	Puttur	12.7687° N	75.2071° E	87	Cashew plantation	High
	*Koila (KL)	Puttur	12.7687°N	75.2071° E	87	Proposed veterinary college	Moderate
Kasaragod region	Adka (AD)	Kasaragod	12.4387° N	75.2012° E	19	Cashew plantation	High
	Perla (PL)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	High
	*Maniyampara (MN)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	High

	Kumble (KM)	Kumbla	12.4387° N	75.2012° E		Infrastructure, Mining	High
	Seethangoli (ST)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	High
	Posadigumpe (PG)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure, Rubber plantation	Low
	Muligadde (MG)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	High
	Mujungav (MJ)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	High
	*Anathapuram (AP)	Kumbla	12.4387° N	75.2012° E	19	Grazing, Infrastructure	Low
	Kommangala (KM)	Kumbla	12.4387° N	75.2012° E	19	Proposed solar power plant	Low
	*Kotappara (KP)	Hosdurg	12.3059° N	75.0947° E	19	Infrastructure	Low
	Bandadka (BD)	Kasaragod	12.4387° N	75.2012° E	19	Infrastructure	Moderate
	*Periya (PR)	Hosdurg	11.8356° N	75.8563° E	19	Infrastructure	High
Kannur region	*Madayipara (MD)	Kannur	12.0323° N	75.2567° E	1.02	Tourism, Grazing, Mining	Moderate

Table 2.2 Study locations. (* Major plateaus considered for the present study)

Region	Study localities	Field visit date	Important objectives covered
Uttara Kannada		15-7-2015	Early germinating pioneers, Microhabitats, Endemism
		4-8-2015	Heavy monsoon seasonal flora, Microhabitats, Endemism
		28-10-2015	Post monsoon seasonal flora, Microhabitats and Endemism
Dakshina Kannada region	Mukka-Surathkal	2-7-2012,12-7-2012	Microhabitats, Floristic composition
	Kateel	4-8-2012	Microhabitats, Endemism, Ethnobotany
	Neerumarga	7-7-2012,28-7-2012	Microhabitats, Endemism
		17-10-2013	Microhabitats, Endemism
	Valachil	18-8-2012,20-8-2012	Early germinating pioneers, Microhabitats, Endemism
		2-8-2013,12-8-2013	Heavy monsoon seasonal flora, Microhabitats, Endemism
		21-10-2013,26-10-2013	Post monsoon seasonal flora, Microhabitats and Endemism
	Konaje	Regular fieldwork Conducted (2 days/week) during 2011-2017.	This plateau is exclusively selected for seasonal succession and phenology studies along with other aspects.
	Mudipu	4-7-2015,12-7-2015	Microhabitats, Endemism, Ethnobotany
	Neerpaaje	2-7-2014,12-8-2015	Microhabitats, Endemism
	Koila	20-6-2016	Pre-monsoon phase
		30-7-2016	Heavy monsoon phase
		12-11-2016	Post monsoon phase

Kasaragod region	Adka	27-7-2012,12-7-2013	Microhabitats, Endemism
	Perla	22-7-2012,15-7-2013	Microhabitats, Endemism
	Maniyampara	2-7-2012,12-7-2015	Early germinating pioneers, Microhabitats, Endemism
		2-8-2014,12-9-2014	Heavy monsoon seasonal flora, Microhabitats, Endemism
		20-7-2012,12-8-2012	Post monsoon seasonal flora, Microhabitats and Endemism
	Kumble	29-7-2012,12-8-2012	Microhabitats, Endemism
	Seethangoli	30-7-2012,15-8-2012	Microhabitats, Endemism, Ethnobotany
	Posadigumpe & Muligadde	25-7-2014	Microhabitats, Endemism, Ethnobotany
		20-10-2014	Post monsoon seasonal flora and microhabitats
	Permude	30-8-2013	Microhabitats, Endemism, Ethnobotany
	Mujungav	20-7-2016,25-8-2016	Microhabitats, Endemism, Ethnobotany
	Anathapuram	22-7-2017,17-12-2017	Microhabitats, Endemism, Ethnobotany
	Kommangala	23-8-2017	Microhabitats, Endemism
	Kotappara	7-7-2012,12-8-2011	Early germinating pioneers, Microhabitats, Endemism
		2-8-2011,2-9-2011	Heavy monsoon seasonal flora, Microhabitats, Endemism
		12-10-2012,15-10-2012	Post monsoon seasonal flora, Microhabitats and Endemism
	Bandadka	19-6-2012,28-9-2012	Microhabitats, Endemism, Ethnobotany
	Periya	6-7-2012,29-7-2012	Microhabitats, Endemism
Kannur region	Madayipara	28-7-2013	Early germinating pioneers, Microhabitats, Endemism
		2-8-2013	Heavy monsoon seasonal flora, Microhabitats, Endemism
		2-10-2013,12-10-2014	Post monsoon seasonal flora, Microhabitats and Endemism

Table 2.3: Details of field visit date and details studied.

2.2.2: Plant collection: The plants were collected based on standard field guides (British Columbia,1996; Jane, 2004). The collected specimen was carried in polyethylene bags/paper bags during field trips. Delicate flowers were preserved in 70% alcohol for further detailed morphological studies. Field data has been noted in the field diary. Photographs are taken by using NIKON DSLR D5600 camera and Nikon stereo binocular microscope.

2.2.3: Identification of plants

Plants were identified by using relevant local and regional floras (Gamble,1915-1936; Yoganarasimhan and Razi, 1982; Ramaswamy & Razi,1973; Ramaswamy et al., 2001; Bhat, 2003 & 2014; Ingalhalikar, 2007), revisionary works (Janarthanam &Henry,1984; Ansari & Balakrishnan,1994 & 2009; Thiv,2003; Shahina and Nampy,2014) and online services. Identity of each specimen was compared with protologues and types deposited in various herbaria such as G, K, M, N, P (online services).

Data on distribution of species and accepted names were followed by using websites:

http://www.plants of the world online.org.
www.ipni.org,orldfloraonline.org/taxon/wfo.

http://www.worldfloraonline.org.

https://indiabiodiversity.org/species/show/252770.

https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:399300-1.

Common name and ethnobotanical uses of plants were also gathered by interacting with locals. Detailed information about edible uses, medicinal benefits and other uses were collected and documented.

2.2.4: Raunkiaers life forms and conservation status

Life-forms have been classified as per Raunkiaer (1934). The status of the species was assigned as per the IUCN Red List Categories and Criteria Version 3.1 (IUCN, 2021).

2.2.5: Preparation of Herbarium

The herbarium specimens were prepared as per standard specification (Fosberg & Sachet, 1965; Bridson & Forman, 1991). Voucher specimens are deposited at Herbarium, Department of Applied Botany, Mangalore University.

2.2.6: Study on vegetation composition

A thorough survey has been conducted to assess species diversity and distribution of herbaceous plants during the period of October 2012 to March 2015 in selected study sites. All the herbaceous plants species were recorded within the representative quadrats. Similarly, the plants found along the marshy areas, on rocks that could not occur within the regular quadrat area were randomly observed, recorded and included. Seasonal succession and phenological changes in the community were clearly noted by direct observation and regular documentation. This was done weekly from the beginning of the rainy season i.e., 1 June 2015 until 30 November 2015. From the middle of June until the end of the growing season in late October, counts were made fortnightly. Konaje plateau (12.8170° N and 74.9231° E) was exclusively considered for Phenology and seasonal succession studies. This alone consist of different microhabitats with interesting species composition.

Sampling design: In ecology and geography, a quadrat is a square frame used to isolate a standard unit of area for studying the distribution of an item over a vast area. To record biodiversity (alpha diversity) within the chosen region, the traditional process of visual estimation using the quadrat method was used. Following standardization, the quadrat size was fixed at 1 sq. meter while the minimum number of quadrats was found to be 10 for each estimation. In each selected area 10 quadrats of 1m×1m, were laid along a straight line (transect line), leaving a distance of 10 m between any two successive quadrats. To increase efficiency of estimation, quadrats were randomly placed in each site per season.

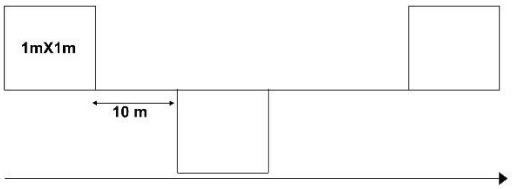


Figure 2.3: Line transact outline for this study.

2.2.7: Distribution pattern of plants

Based on distribution of herbaceous taxa in the LRO's, we have considered two categories in the present work. They are, i) Plateau specificity of species, ii) Species specific to microhabitats.

2.2.8: Diversity indices

- **Shannon –Weiner index (H):**

  $(H)=-\sum [(ni/N) \log 2 (ni/N)]$

  Where, H is Shannon –Weiner index, calculated to the base 2 of species diversity; ni number of individuals of a species i; N= total number of individuals of all species in the community.

- **Simpson's index:** Index of dominance $(C)=\sum [ni/N] 2$

  Simpson's Index of Diversity 1-D:

  $$D = 1-\left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

  Where, n = the total number of a particular species, N = the total number of all species.

- **Species richness index (R):** $R = S/ \sqrt{N}$ Where, R= Menhinick's index of species richness; S= Number of a species in a collection; N= Number of individuals collected.
- **Evenness_EH/S:** Calculates Pielou's measure of species evenness, i.e. J = H'/ln(S) where H' is Shannon Weiner diversity and S is the total number of species in a sample, across all samples in a dataset.
- **Brilliouin index (H_B)**

  $$H_B = \frac{\ln(N!) - \sum \ln(ni!)}{N}$$

  where, N is the total number of individuals in the community, n is the number of individuals in the i^{th} species.

- **Menhinick (M):** Menhinick's index is simply the number of species (n) divided by the square-root of the total number of individuals (N).
- **Margalef's index:** Margalef's index = (S – 1) / In N. where, S = total number of species, N = total number of individuals in the sample, In = natural logarithm

- **Evenness:** e = H / In S. where, H = Shannon – Wiener diversity index S = total number of species in the sample
- **Fisher-alpha:** Fisher's alpha is a good scale-independent biodiversity measure. However, in communities where the spatial distribution of individuals is heavily concentrated or if the overall number of species does not approach to infinity, alpha may be overestimated.
- **Berger_Parker:** The Berger–Parker index equals the maximum p_i value in the dataset, i.e., the proportional abundance of the most abundant type. This corresponds to the weighted generalized mean of the p_i values when q approaches infinity, and hence equals the inverse of the true diversity of order infinity ($1/^{\infty}D$).
- **Equitability:** Shannon's equitability (E_H) can be calculated by dividing H by H_{max} (here H_{max} = lnS). Equitability assumes a value between 0 and 1 with 1 being complete evenness.
- **Chao_1**: Chao1 is a nonparametric approach for calculating the number of species in a population. The Chao richness estimate was created by Anne Chao and is based on the principle that rare species provide the most information about the number of missing species.
- **Density:** The population size and density for the full population can be calculated using sample data. The population density is computed by dividing the number of units of area or space by the number of individuals present at a given time in a given space. Population density is calculated as follows:

  Density = (Total no. of individuals of the species in all the sampling unit (S))/ (Total number of sampling units studied (Q)).
- **Frequency:** The degree of regularity of the presence of individuals of a species within a plant community is defined as frequency. The quadrat method is a frequently utilised method for plant frequency sampling.

  After the sample data has been analysed, the scientist can use the following approach to compute the population frequency of the full population:

  %Frequency = (Number of sampling units in which the species occurs)/ (Total number of sampling units employed for the study) *100
- **Abundance** = Total number of individuals of the species × 100 / Total number of quadrates in which the species has occurred.

- **IVI** = Relative density + Relative frequency + Relative abundance

2.3.1: Classification of microhabitats

The microhabitats were classified based on overall appearance, edaphic properties, water availability and species composition. All existing classifications attempted in other rocky plateaus of Western Ghats and other regions were referred while classifying microhabitats (Porembski & Barthlott, 2000; Jacobi et al., (2007); Watve,2013; Lekhak and Yadav,2012; Sreejith et al.,2016).

The microhabitats classified were further analysed for their similarity in species composition by Sorensen's Similarity index using the formula:

Sorensen's Similarity index $S=2C/(A+B)$

Where S= Similarity index; A= number of species in sample; B= number of species in sample; C=number of species in sample common to A and B both.

2.3.2: Soil analysis

Soil samples were collected from different microhabitats present in the study location. The samples were collected using soil borer from the surface and depth of 0-10 cm. The collected samples from the site were mixed thoroughly, air dried and passed through a 2 mm mesh sieve to remove debris, stone and roots.

Following parameters were taken for soil analysis:

- PH- Using digital PH meter.
- Total nitrogen by Kjeldal method (1883).
- Available phosphorous by Bray et al., (1945) method.
- Availability of Potassium by flame photometer.
- Organic Carbon by Wakley and Black Method (1934).

2.4.1: Phenology studies

Selection of plants and data sources: A total of 26 representative species from different types of microhabitats from various families have been selected for study**.** These belong to 16 families, containing 5 species of Poaceae, 3 species of Lentibulariaceae, 2 species of Asteraceae and Eriocaulaceae each and 1 species each from Burmanniaceae, Droseraceae, Rubiaceae, Lythraceae, Commelinaceae and Fabaceae (**Table.4.1**).

The starting date for a given phenophase was observed from a permanently marked individual selected from a group of more than ten individuals. Infected or injured plants were avoided from the study. Vegetative phase was observed from germination stage to fully developed mature leafy stage. Flowering was determined by first opened flower seen on any tagged plant and considered as the first flowering day for that particular specimen of the species, while the last flowering day was when only a single flower remained on any tagged plant of the species. In the case of first fruiting day, initiation of fruit on any tagged plant of the species was considered, whereas ripening of fruit was considered as the last fruiting day. Finally, mean value of all tagged plants was converted into mean data for each species for a particular phenological trait, viz. first flowering day (FFD) and first fruiting day (FFRD) etc.

2.5.1: Succession studies

A total of 57 species were recorded from permanent sample plots. In every data collection only plants exhibiting flowering phenology were selected. Certain species are likely to have dominating appearance in particular phases of succession and they tend to appear in other phases also. Still, to avoid confusions in interpretations their presence is continuously recorded in each phase.

2.6: Statistical analysis

2.6.1: Principal component analysis (PCA)

PCA was carried out using the package PAST version 2.16. The goal of principal component analysis is to minimise the dimensionality of a data set that contains a high number of interrelated variables, while maintaining as much variance as possible (Jolliffe, 2002; Labib and Vemuri, 2005).

2.6.2: Canonical analysis:

To analyse the relationship among environmental variables, herbaceous species and sampling sites, we performed a canonical correspondence analysis (CCA) using MVSP version 3.11.

2.6.3: Cluster analysis (CA)

Morista similarity analysis: To verify the degree of similarity between sampling sites, considering taxonomic richness and floristic abundance, we performed a modified Morista similarity analysis (UPGMA method, MVSP version 3.11).

For clustering similar sampling units of monsoon flora showing succession stages, chord distance co-efficient computation method was carried out using a PAST program and dendrograms prepared.

2.7.1: Analysis of Data

To interpret the data, to analyse the information and results, sources are gathered from available literature and expert opinion from statistician was taken. Data for all the study locations with respect to monsoon flora for the entire study period was tabulated and the following indices determined by using the package PAST version 2.16.The data is presented mainly by using graphs and tabular columns and photographs.

For evaluating variation in phenology among 26 species, one-way ANOVA was performed using Origin Pro-8 software. All descriptive statistics, average, standard deviation, minimum and maximum were obtained using MS Excel-2010. For pooled analysis of correlation, average values of all parameters for all study years were calculated, and then correlation between phenological and climatic parameters was obtained. For studying variation in FFD and FFRD, the number of days after 1 June for each year was calculated. Two-way ANOVA and linear correlation were performed using the software PAST. On the basis of data for 5 years and average plus standard deviation and average minus standard deviation, the species with highest, medium and lowest number of days for flowering and fruiting were identified. If the pooled value of species was above average plus deviation, then it was grouped under ‘species with long flowering or fruiting duration. If the pooled value was below the average minus deviation, then it is grouped under with medium flowering or fruiting duration’.

RESULTS

3.1.1: Floristic composition

Analysis of the floristic diversity in the Southern coastal grassland plateaus resulted in recording a total of 393 herbaceous species. Of the flora documented, 43.9 % were monocots and remaining 54.7% eudicots. Herbaceous plants recorded were belonging to 25 orders, 188 genera and 54 families (Table 3.10). 7 orders are from monocots, and 17 are from eudicots especially super rosids and superasterides as depicted in Figure 3.1.

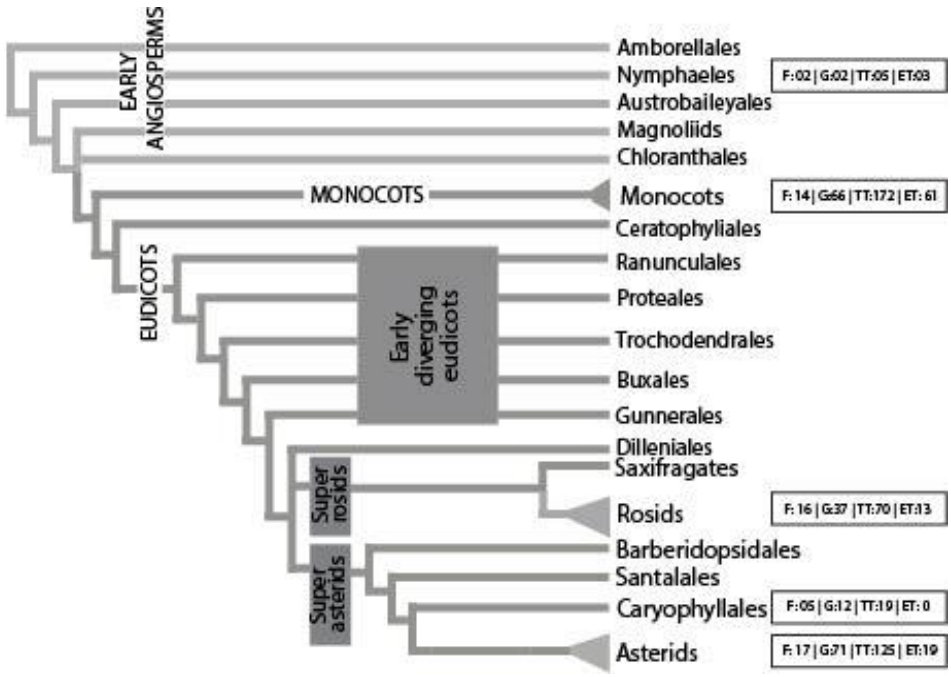
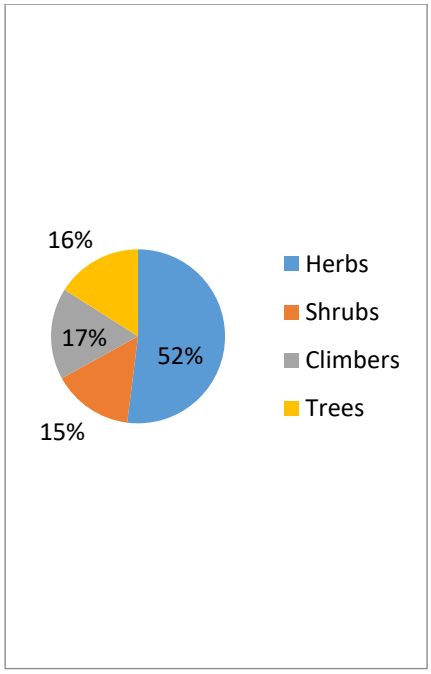


Figure 3.1: Overview of systematic composition of herbaceous taxa in study area (According APG IV).

Altogether herbs (71.6 %), shrubs (7.16 %), climbers (9.31 %) and trees (11.8%) contribute to the flowering plants of this ecosystem (Figure 3.2). Distribution of orders, families, total taxa and endemic taxa in major clades of APG IV classification are given in Figure 3.3. Information on the lifeform, habit, habitat, phenology and phytogeographic distribution of herbaceous species recorded during the present study are given in Annexure I.



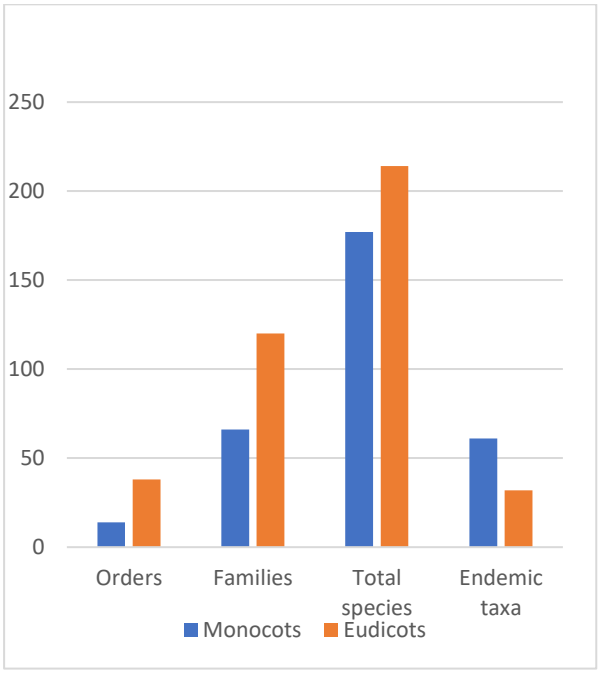


Figure 3.2: Percentage distribution of habit forms of the documented species.

Figure 3.3: Distribut taxa plant & endemic IV classification

3.1.2: Family wise distribution

The most speciose-families in the plateaus are Poaceae followed by Fabaceae and Rubiaceae with high number of therophytes (Table.3.1). Asteraceae represented high number of invasive weeds. Acanthaceae represented drought enduring perennials. Orobancaceae represented root parasites.

Serial No	**Family**	**No. of genera**	**No. of species**
1.	Poaceae	37	94
2.	Fabaceae	10	23
3.	Rubiaceae	7	19
4.	Asteraceae	20	23
5.	Acanthaceae	8	16
6.	Commelinaceae	3	12

7.	Gentianaceae	4	12
8.	Euphorbiaceae	3	12
9.	Cyperaceae	7	13
10.	Orobancaceae	6	10

Table 3.1: Top herbaceous plants rich families in the study region.

3.1.3: Generic level distribution

Some of the genera in the plateaus are characteristically species rich. Families with largest number of herbaceous genera were Poaceae, Asteraceae followed by Fabaceae. *Eriocaulon* has the highest number of species (16), followed by *Ischaemum* (11), *Utricularia* (10), *Isachne* (10) and *Spermacoce* (8). (Table 3.2). *Commelina*, *Arundinella*, *Eragrostis* were represented by five species each. *Blyxa*, *Arthraxon*, *Glyphochloa*, *Panicum*, *Crotalaria*, *Desmodium*, *Justicia* and *Blumea* are represented by four species each. *Cyanotis*, *Fimbristylis*, *Garnotia*, *Heteropogon*, *Paspalum*, *Alysicarpus*, *Phyllanthus*, *Amaranthus*, *Canscora* are represented by three species each. We have also observed that generic level representations from each plateau differs significantly. Therefore, flowering phenological pattern significantly differs even between very closely located plateaus. It is also clearly observed that generic level representations are very specific in each small or larger plateaus. Dominant generic level distribution pattern characteristic to different plateau is given in Figure 3.4.

Sl. No	**Generic name**	**No. of species**
1.	*Eriocaulon*	16
2.	*Ischaemum*	11
3.	*Utricularia*	10
4.	*Isachne*	10
5.	*Rotala*	9
6.	*Dimeria*	8
7.	*Spermacoce*	8
8.	*Dichanthium*	7
9.	*Exacum*	6
10.	*Commelina*	5

11.	*Arundinella*	5
12.	*Eragrostis*	5

Table 3.2: Most speciose genera in the study region.

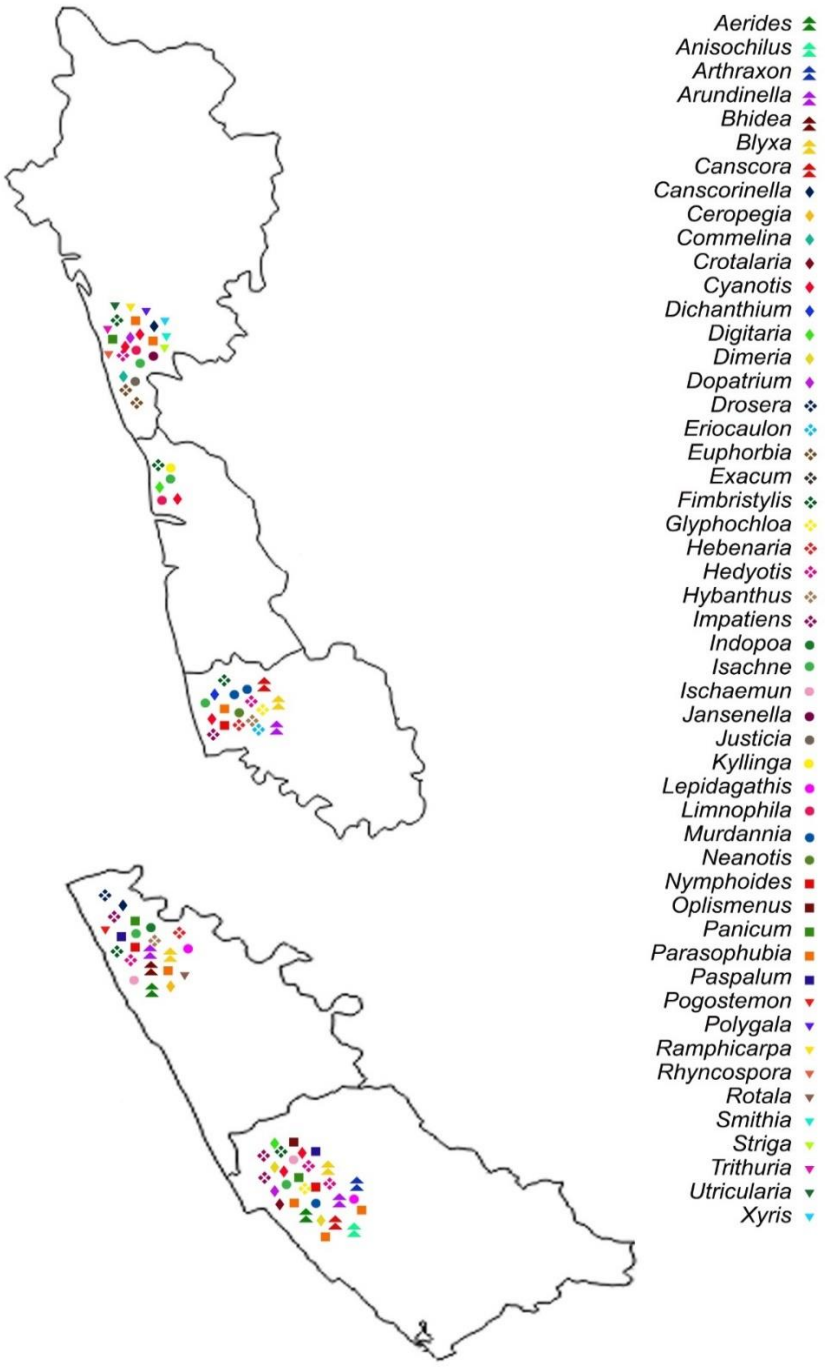


Figure 3.4: Dominant generic level distribution pattern characteristic to different plateau.

3.1.4: Spatial distribution of species

Depending on endemism, altitudinal ranges or microhabitat preferences, the species' distribution can be defined in a variety of ways. In the studied region, there are restricted endemics, endemics to Peninsular India, Indian endemics, broadly spread, and so on, all of which contribute to the species' unique spatial distribution pattern (Figure.3.5).

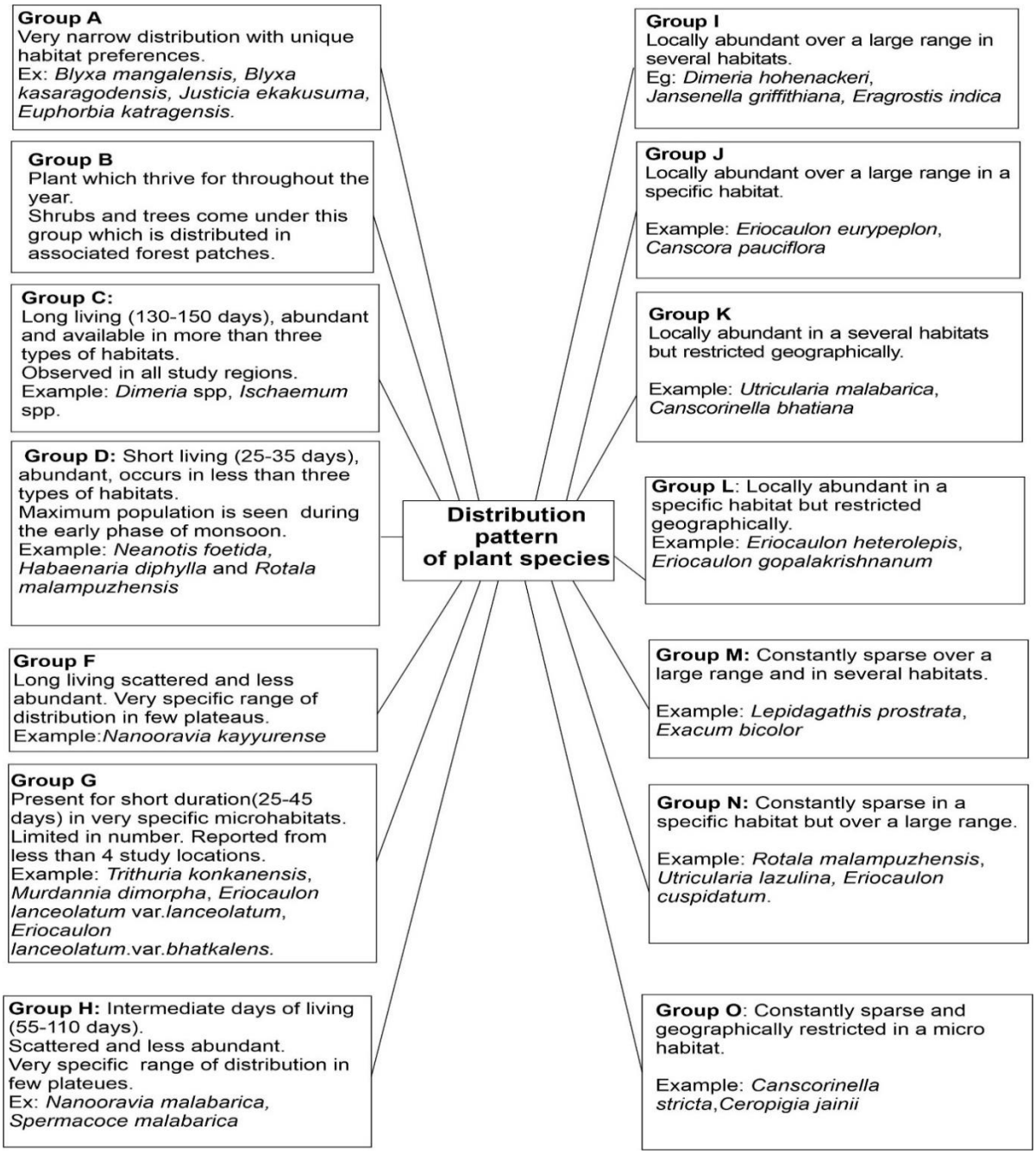

Distribution pattern of plant species
Group A
Very narrow distribution with unique habitat preferences.
Ex: Blyxa mangalensis, Blyxa kasaragodensis, Justicia ekakusuma, Euphorbia katragensis.
Group B
Plant which thrive for throughout the year.
Shrubs and trees come under this group which is distributed in associated forest patches.
Group C:
Long living (130-150 days), abundant and available in more than three types of habitats.
Observed in all study regions.
Example: Dimeria spp, Ischaemum spp.
Group D: Short living (25-35 days), abundant, occurs in less than three types of habitats.
Maximum population is seen during the early phase of monsoon.
Example: Neanotis foetida, Habaenaria diphylla and Rotala malampuzhensis
Group F
Long living scattered and less abundant. Very specific range of distribution in few plateaus.
Example:Nanooravia kayyurense
Group G
Present for short duration(25-45 days) in very specific microhabitats.
Limited in number. Reported from less than 4 study locations.
Example: Trithuria konkanensis, Murdannia dimorpha, Eriocaulon lanceolatum var.lanceolatum, Eriocaulon lanceolatum.var.bhatkalens.
Group H: Intermediate days of living (55-110 days).
Scattered and less abundant.
Very specific range of distribution in few plateues.
Ex: Nanooravia malabarica, Spermacoce malabarica
Group I
Locally abundant over a large range in several habitats.
Eg: Dimeria hohenackeri, Jansenella griffithiana, Eragrostis indica
Group J
Locally abundant over a large range in a specific habitat.
Example: Eriocaulon eurypeplon, Canscora pauciflora
Group K
Locally abundant in a several habitats but restricted geographically.
Example: Utricularia malabarica, Canscorinella bhatiana
Group L: Locally abundant in a specific habitat but restricted geographically.
Example: Eriocaulon heterolepis, Eriocaulon gopalakrishnanum
Group M: Constantly sparse over a large range and in several habitats.
Example: Lepidagathis prostrata, Exacum bicolor
Group N: Constantly sparse in a specific habitat but over a large range.
Example: Rotala malampuzhensis, Utricularia lazulina, Eriocaulon cuspidatum.
Group O: Constantly sparse and geographically restricted in a micro habitat.
Example: Canscorinella stricta,Ceropigia jainii

Figure 3.5: Spatial distribution of plant species in the study region.

3.1.5: Species representation in the study region

In this study, we have clearly noted most speciose rich families and genera occurring in each plateau. The dominant species found in most of the study region were *Eragrostis indica*, *Dimeria hohenackeri*, *Impatiens minor*, *Eriocaulon eurypeplon* etc. Whereas, few species were specifically representing the plateaus.

Dakshina kanaada region

Konaje, Valachil, Mudipu, Neerumarga and Kateel are the associated plateaus in this region. *Crotalaria quinquefolia, Blyxa mangalensis*, *Eriocaulon cuspidatum*, *Ischaemum mangaloricum*, *Rotala malampuzhensis*, *Iphiginia indica*, *Neanotis foetida* were frequent in Konaje. Very few species of *Hebanaria*'s and *Rotala*'s were sparsely distributed in Konaje and Valachil. *Oldenlania dichotama* is a dominant herb in Neerumarga. Whereas *Canscora paucifolia*, *Utricularia malabarica*, *Fimbristylis tenera*, *Eriocaulon cheemenianum*, *Smithia conferta* were equally well distributed.

Begonia crenata, *Utricularia striatula*, *Eriocaulon balakrishnannii*, *Canscorinella stricta*, *Eriocaulon lanceolatum* var. *lanceolatum* were abundant in Valachil. Colorful flowering species like *Iphiginia indica, Gloriosa superba* and presence of *Asperagus recemosus*, *Rauvolphia serpentina* make the area home to most important genera. The other species having higher density were *Osbeckia muralis, Hoppea fastigata, Hoppea dichotoma* and *Eragrostis indica. Canscora bicolor, Spermacoce malabarica, Parasopubia delphinifolia* and *Striga gesneroides* (Table.3.3).

Species name	**F**	**D**	**Ab**	**IVI**
Eriocaulon eurypeplon	0.50	3.10	3.80	16.36
Begonia crenata	0.40	0.15	1.00	1.21
Blyxa mangalensis	0.15	0.35	1.75	3.70
Crotalaria quinquefolia	0.90	8.05	8.63	21.55
Canscora pauciflora	0.90	1.05	2.63	7.55
Canscorinella stricta	0.15	0.35	1.75	1.70
Crotalaria quinquifolia	0.15	0.35	1.75	3.70
Eriocaulon lanceolatum var. *lanceolatum*	0.90	1.05	2.63	7.55
Eriocaulon cheemenianum	0.80	3.10	3.20	4.46

Eriocaulon cuspidatum	0.50	3.10	4.43	6.36
Exacum lawii	0.20	0.35	1.46	2.65
Fimbristylis tenera	0.50	3.10	4.43	16.36
Iphiginia indica	0.25	0.65	4.33	6.44
Ischaemum mangaloricum	0.15	1.80	3.20	5.46
Liparis rheedii	0.90	1.05	1.63	1.55
Neanotis foetida	0.40	0.15	1.00	2.21
Osbeckia muralis	0.40	0.15	1.00	2.21
Parasopubia delphinifolia	0.25	0.65	1.33	1.44
Murdannia semepteris	0.25	0.65	4.33	6.44
Rotala malampuzhensis	0.35	0.10	2.00	1.33
Smithia conferta	0.35	0.10	2.00	2.33
Spermacoce malabarica	0.35	0.10	2.00	2.33
Trithuria konkanensis	0.05	0.10	1.98	1.23
Utricularia striatula	0.40	0.15	1.00	1.21

Table 3.3: Frequency, density, abundance and IVI value of notable herbs in different plateaus of Dakshina Kannada region.

Kasaragod region

Maniyampara, Posadigumpe, Mujungav, Kumble, Seethangoli, Permude, Kommangala, Adka, Perla are closely associated plateau of this region. Maniyampara plateau represented *Pogostemon deccanensis*, *Blyxa octandra*, *Rotala dhaneshiana*, *Rotala malampuzhensis*, *Nanooravia malabarica* etc., which were more frequent. Recently reported *Isachne bhatii*, *Hedyotis kurzii* are common here. The higher relative density was recorded for Kumble, Seethangoli and Permude areas consist of *Anisochilus indica*, *Geissapsis cristata*, *Arundinella metzii* with the frequency of 0.15-0.45. *Drosera indica*, *Utricularia malabarica* and *Fimbristylis woodrowii* occurred in all quadrats of Kommanagala plateau. Compared to other plateaus this plateau had represented least number of species. Mujungavu represented large patches of *Utricularia* spp, *Canscora spp* and *Eriocaulon* spp. The sparsely distributed south

Indian endemic *Euphorbia katrajensis* is seen here. Posadigumpe grassy hillock also shows presence of medicinal plants like *Hybanthus ennaspermus* and *Pogostemon quadrifolius*. Recently reported *Rotala dhaneshiana*, *Isachne bhatii* are seen exclusively in this region. Sparsely distributed *Ceropigia jainii* is observed Periya plateau. *Lepidagathis clavata*, *Ramphicarpa fistulosa*, endemic *Euphorbia katrajensis*, *Canscorinella bhatii* were most abundant species in Ananthapuram. *Eriocaulon gopalakrishnanum*, *Ischaemum cannanorensis*, *Ischaemum copeanum*, *Dicanthium oliganthum* are commonly seen in Kotappara and Bandadka plateaus (Table.3.4).

Species name	**F**	**D**	**Ab**	**IVI**
Anisochilus indica	0.25	0.35	1.75	3.70
Arundinella metzii	0.05	0.55	1.60	4.01
Blyxa octandra	0.15	0.80	3.20	6.46
Canscorinella bhatii	0.50	0.45	0.40	0.40
Ceropigia jainii	0.20	0.10	1.33	1.44
Euphorbia katrajensis	0.70	0.10	1.60	4.01
Dicanthium oliganthum	0.58	0.86	2.12	1.99
Drosera indica	0.60	0.20	2.00	2.33
Eriocaulon gopalakrishnanum	0.05	0.80	0.10	0.10
Ischaemum malabaricum	0.10	0.20	6.20	16.67
Geissapsis cristata	0.20	0.20	2.00	2.90
Hedyotis kurzii	0.90	1.05	2.63	7.55
Hybanthus ennaspermus	0.10	0.85	6.20	16.67
Isachne bhatii	0.40	0.15	1.00	2.21
Ischaemum cannanorensis	0.20	1.35	0.50	0.50
Ischaemum copeanum	0.25	0.35	1.50	3.41
Lepidagathis clavata	0.05	0.50	1.00	2.21
Nanooravia malabarica	0.06	0.70	3.85	5.36
Pogostemon deccanensis	0.50	3.10	4.43	16.36
Pogostemon quadrifolius	0.25	0.65	3.67	6.20

Ramphicarpa fistulosa	0.20	3.10	2.63	7.55
Rotala dhaneshiana	0.35	0.10	2.00	2.33
Rotala malampuzhensis	0.25	0.65	4.33	6.44
Utricularia malabarica	0.05	0.55	1.43	4.75
Xyris indica	0.05	0.65	0.20	0.20

Table 3.4: Frequency, density, abundance and IVI value of notable herbs in different plateaus of Kasaragod region.

Kannur region

Madayipara plateau is known for its abundant biodiversity. Recent study by Pramod and Pradeep (2021), have reported 120 rare and endemic plants from this plateau. Continuous laterite stretches of Madayippara plateau has *Eriocaulon madayiparense*, *Paspalum conjugatum*. The small rocky pools of Madayipara contains *Dopatrium junceum, Rotala malabarica, Eriocaulon cuspidatum.* Grasses like *Dimeria blatteri, Dimeria deccanensis, Dimeria ornithopoda* var. *megalantha, Dimeria stapfiana, Dimeria bialata, Dichanthium oliganthum, Dichanthium panchganiense, Isachne swaminathanii, Ischaemum barbatum, Ischaemum impressum, Ischaemum jayachandranii, Ischaemum elimalayanum, Ischaemum malabaricum, Ischaemum muticum, Ischaemum pappinisseriense* are abundantly seen (Table 3.5).

Species name	**F**	**D**	**Ab**	**IVI**
Alysicarpus bupleurifolius	0.34	0.58	2.36	4.22
Coelachne madayensis	0.12	0.23	1.32	1.28
Dimeria mooneyi	0.15	0.65	4.33	6.44
Dimeria deccanensis	0.15	0.15	1.00	2.21
Dimeria ornithopoda var. *megalantha*	0.40	1.05	2.63	3.55
Dimeria stapfiana	0.20	0.35	1.75	3.70
Eriocaulon odoratum	0.25	0.80	3.20	6.46
Eriocaulon gopalakrishnanum	0.05	0.10	2.00	2.33
Eriocaulon madayiparense	1.00	1.35	2.11	1.78
Curcuma oligantha	0.15	0.55	3.67	6.20
Dichanthium oliganthum	0.50	1.50	3.00	4.68
Dichanthium panchganiense	0.05	0.10	2.00	2.90
Fimbristylis woodrowii	0.10	0.20	2.00	2.90

Isachne swaminathanii	0.20	0.35	1.75	3.70
Ischaemum elimalayanum	0.35	0.50	1.43	4.75
Ischaemum impressum	0.25	0.40	1.60	4.01
Ischaemum jayachandranii	0.05	0.10	2.00	2.33
Ischaemum malabaricum	0.50	3.10	6.20	16.67
Ischaemum muticum	0.15	0.55	3.67	5.67
Ischaemum pappinisseriense	0.25	0.40	1.60	4.01
Cyanotis papilionaceae	0.15	0.36	0.19	0.23
Lepidagathis keralensis	0.05	0.10	2.00	2.33
Paspalum conjugatum	0.70	2.10	2.43	6.36
Rotala malabarica	0.35	0.85	2.43	1.54

Table 3.5: Frequency, density, abundance and IVI value of notable herbs in Madayipara plateau.

Uttara kannada region: *Utricularia uliginosa*, *Utricularia reticulata*, *Utricularia cecelli*, *Polygala elongata*, *Salmonea cantoniensis*, *Bhidea bursiana*, *Dichanthium oliganthum*, *Dimeria moonei*, *Eriocaulon lanceolatum* var. *bhatkalense* occurred in many quadrats (F=3.5-4.43). *Coelachne minuta*, *Geissapsis cristata*, *G. tenella* were less frequent with frequency of 0.25-0.35. *Utricularia'*s, *Impatiens* and *Eriocaulon'*s were abundantly distributed (Table.3.6).

Species name	**F**	**D**	**Ab**	**IVI**
Bhidea bursiana	0.45	0.10	2.00	2.33
Celosia spicata	0.55	0.20	1.35	2.45
Coelachne minuta	0.35	0.30	0.25	1.98
Dicanthium oliganthum	0.25	0.65	4.33	6.44
Dimeria moonei	0.35	0.55	0.46	5.23
Eriocaulon heterolepis	0.35	0.35	1.75	3.70
Eriocaulon lanceolatum var. *bhatkalense*	0.85	1.05	2.63	7.55
Eriocaulon odoratum	0.25	0.12	1.20	1.34
Eriocaulon stellulatum	0.32	0.15	1.00	2.21
Geissapsis cristata	0.15	0.10	0.08	1.0
Geissapsis tenella	0.15	0.12	0.07	1.34

Glyphochloa acuminata	0.15	0.80	3.20	6.46
Impatiens pulcherrima	0.25	0.65	4.33	6.44
Indigofera dalzeli	0.50	3.10	4.43	5.45
Ischaemum yadavii	0.25	0.80	3.20	6.46
Isachne bhatii	0.25	0.35	1.75	3.70
Jansenella neglecta	0.35	0.10	2.00	2.33
Microchloa indica	0.40	0.15	1.00	2.21
Murdannia crocera	0.35	0.35	1.54	2.30
Murdannia dimorpha	0.15	0.80	3.20	6.46
Polygala elongata	0.95	0.35	1.75	3.70
Salmonea cantoniensis	0.50	3.10	4.43	1.36
Utricularia cecelli	0.20	1.05	2.63	7.55
Utricularia graminifolia	0.50	3.10	4.43	4.36
Utricularia uliginosa	0.25	0.65	4.33	6.44
Utricularia reticulata	0.40	0.15	1.00	2.21

Table 3.6: Frequency, density, abundance and IVI value of notable herbs in Bhatkal plateau.

3.1.6: α- Diversity indices

In the present investigation we have calculated the diversity indices of these plateaus. When compared with the diversity indices among the study sites, Madayipara is the most species rich having Shannon diversity index H=3.456 and Simpson value D= 0.9556 followed by Bhatkala with Shannon diversity index H=3.898, and Simpson value D= 0.9534. Whereas Koila plateau was less species rich with Shannon diversity index H=2.157, and Simpson value D= 0.5834 (Table 3.7).

Diversity index	**BT**	**MD**	**MN**	**AP**	**NM**	**KJ**	**KP**	**VL**	**KL**
Taxa_S	53	64	43	35	34	45	32	33	28
Individuals	812	789	517	413	254	534	478	510	604
Dominance_D	0.1567	0.1956	0.6402	0.4986	0.4466	0.6259	0.4356	0.4564	0.03459
Simpson_1-D	0.9534	0.9556	0.8735	0.8867	0.8556	0.9255	0.7451	0.9502	0.5833
Shannon_H	3.898	3.956	2.983	2.946	2.858	3.752	2.499	3.357	2.157

Evenness_EH/S	0.6123	0.6231	0.5578	0.5243	0.5538	0.6274	0.5678	0.5674	0.6012
Equitability	0.8761	0.8721	0.8721	0.8721	0.8721	0.8721	0.8721	0.8721	0.8721
Fisher_alpha	0.8758	0.9345	0.8654	0.8907	0.8723	0.6745	0.6712	0.6156	0.5764
Fisher_alpha	11.32	12.42	9.91	7.91	9.54	10.23	9.34	11.13	6.89

Table 3.7: α- Diversity indices in different study regions.

3.1.7: Morista β-diversity indices

Analysis of the niche sharing of different species between study sites by calculating Morista index (Figure 3.6) revealed the existence of two groupings. The first grouping was formed by two large plateaus (MD and BT) with 42% similarity. This grouping shared the plants belonging to *Utricularia*, *Eriocaulon*, *Crotalaria*, *Geissapsis*, *Dimeria*, *Jansenella*, *Ischaemum* etc. The second grouping was linked to small plateaus of different study regions, where NM and KJ shared similar types of habitats with good number of hydrophytes. For example, *Trithuria konkanensis*, *Blyxa mangalensis* and *Crotalaria quinquefolia* are common here. Stunted growth of *Rauvolfia serpentina*, *Asparagus racemosus*, *Aristolochia indica* are common in Valachil and Koila plateaus. Maniyampara and Anathapuram shared *Pogostemon* spp and *Rotala* spp. The sampling sites that were most related in perennial composition were Kotappara and Periya. They shared *Brachystelma* spp and few lesser known medicinal species. Nine notable plateaus with their significant species representation are given in Figure 3.7.

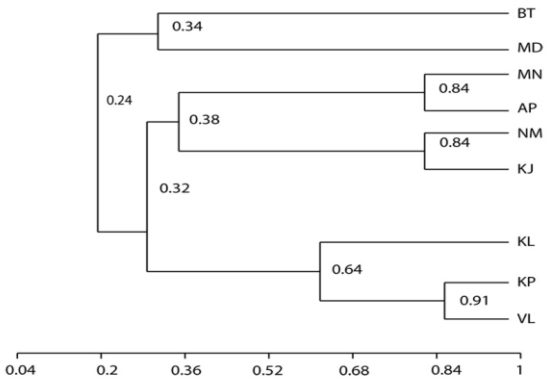


Figure 3.6: Modified Morisita's Cluster showing similarity in species composition.

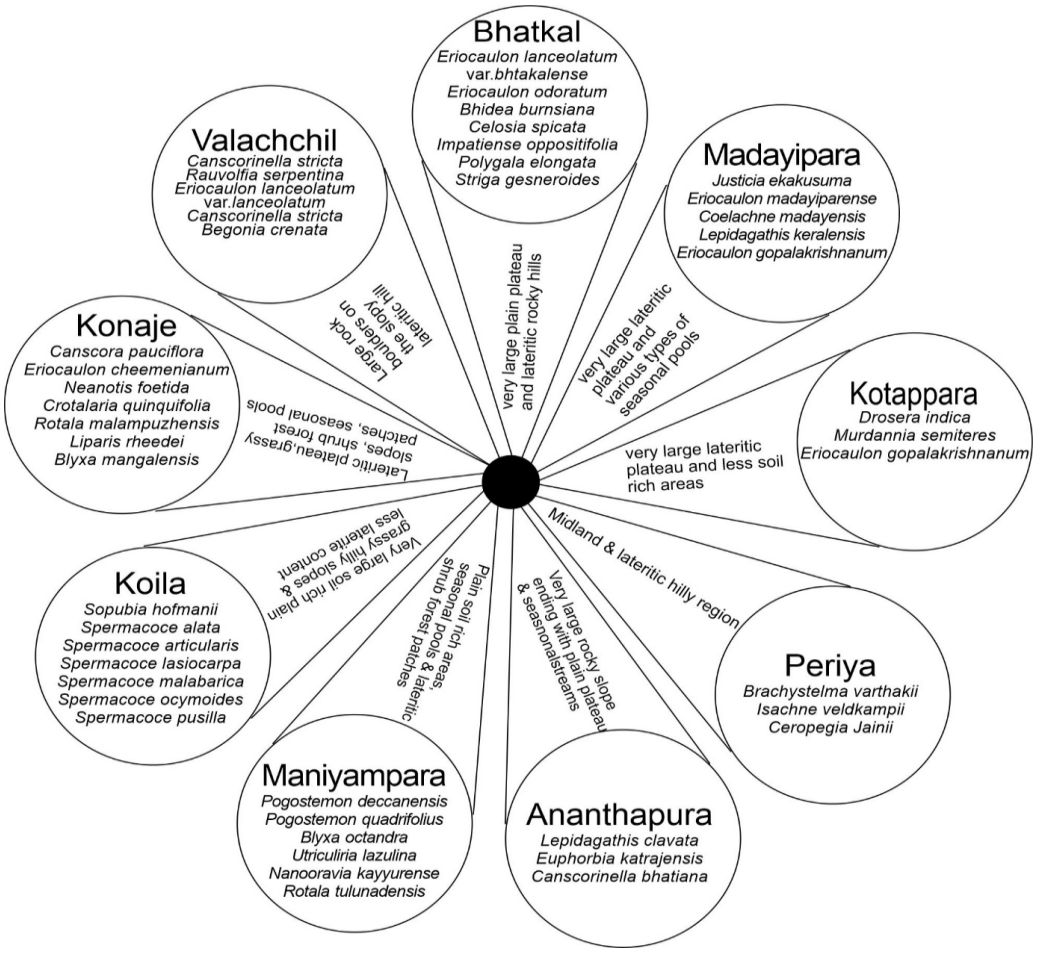


Figure 3.7: Nine notable plateaus with their species representation.

3.1.8: Principal component analysis

Principal component of floristic composition showed three possible groups (Figure. 3.8). The larger absolute value of the coefficient in Bhatkal, Konaje and Madayipara regions show that great number of variabilities exist in different plateaus. The PCA shows that the first axis had 48.8% of cumulative variance followed by second axis 19.7%. Rare and endemic species composition played major role in the direction and length of each points. Some plateaus share similar environmental and spatial structure, still they accommodate distinct floristic composition. The loading scores obtained in PCA indicates that the prime factors responsible for variability is the distribution of rare and endemic species which prefers to grow in different types of microhabitats.

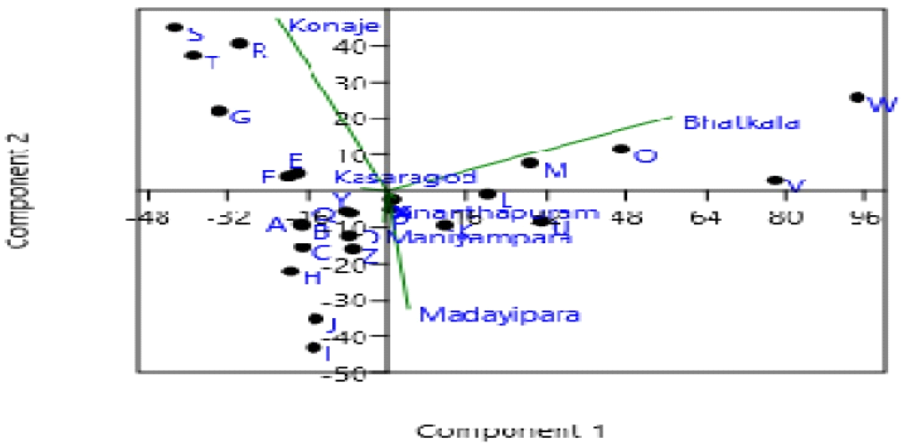


Figure 3.8: Multiple component analysis of important monsoon herbaceous flora in different plateaus.

3.2.1: Rarity and endemism

Out of 391 herbaceous species recorded in this study, 96 are Western Ghats endemics; of which 25 are narrow endemics of Kerala and Karnataka, confined to low altitude grassland plateaus. 41 species are Indian endemics and 7 species are endemic to Peninsular Indian and Sri Lanka. 74 species are in Least Concern (LC) category as per the IUCN Red List Categories and Criteria Version 3.1 (IUCN, 2021). Two species each are Data Deficient (DD) and not evaluated (NE) while two species are Critically Endangered (CR), 2 are Endangered (EN), one species is nearly threatened.

3.2.2: Distribution of rare and endemic herbaceous

Of the plateaus studied, Madayipara and Bhatkala region have maximum number of endemics followed by Dakshina Kannada region. Each plateau differs in the environmental conditions, hence pattern of endemic species composition also varied significantly among the plateaus**.** Distribution of rare and endemic herbaceous plants with reference to different plateaus are given in Table 3.8. Distribution of rare and endemic species recorded in the plateaus is depicted in Figure 3.8.

Sr. No.	Family	Species	Type locality as per protologue	Current report from the present study region
1.	Acanthaceae	*Justicia ekakusuma*	Madayipara (KL)	Madayipara (KL)
2.	Acanthaceae	*Lepidagathis keralensis*	Madayipara (KL)	Madayipara (KL)
3.	Acanthaceae	*Lepidagathis prostrata*	Dakshina kannada (KA), Madayipara (KL), Kas and Chaukul (MH)	Kasaragod, Madayipara (KL), Dakshina Kannada and Bhatkal
4.	Acanthaceae	*Lepidagathis clavata*	Ananthapuram (KL), Chorla Ghat (KA) and Chaukul plateau (MH)	Ananthapara (KL)
5.	Alismataceae	*Wiesneria triandra*	Mujungav to Madayipara (KL), Konaje (KA)	Mujungavu (KL)
6.	Araceae	*Arisaema tortuosum*	Castle rock (KA), Sindhurg (MH), Kannur (KL)	Konaje (KA)
7.	Areceae	*Ariopsis peltata*	South India	Valachi, Koanje (KA)
8.	Asclepiadiaceae	*Ceropegia attenuata*	Kasaragod (KL), Pune, Raigad, Ratnagiri, Thane (MH).	Kotappara, Peria (KL)
9.	Asclepiadaceae	*Ceropegia jainii*	Kotappara, Kasaragod (KL), Satara, Sindhudurg (MH).	Kotappara, Peria (KL)
10.	Asteraceae	*Adenoon indicum*	Bombay (MH)	Kasaragod (KL)
11.	Balsaminaceae	*Impatiens pulcherrima*	South India	Bhatkal (KA)
12.	Begoniaceae	*Begonia malabarica*	South India	Valachil (KA), Kumble (KL)
13.	Colchiaceae	*Iphiginia pallida*	Kasaragod	Konaje and Kumbla, Ananthapuram (KL)
14.	Commelinaceae	*Cyanotis papilionaceae*	Madayipara (KL), Kas plateau	Madayipara (KL), Bhatkal
15.	Commelinaceae	*Murdannia dimorpha*	Kasaragod, Idukki, Pathanamthitta, Kannur, Kollam, Thiruvananthapuram (KL)	Bhatkal (KA), Madayipara (KL)
16.	Commelinaceae	*Murdannia semepteris*	Kasaragod, Kollam, Pathanamthitta, Thiruvananthapuram, Kozhikkode (KL)	Bhatkal (KA), Madayipara (KL)
17.	Cyperaceae	*Rhynchospora whitiana*	South India	Madayipara and Kasaragod (KL), Bhatkal (KA)
18.	Eriocaulaceae	*Eriocaulon cheemenianum*	Kasaragod (KL)	Konaje, Madayipara and Kasaragod (KL), Bhatkal (KA)
19.	Eriocaulaceae	*Eriocaulon cuspidatum*	Western Ghats	All study regions
20.	Eriocaulaceae	*Eriocaulon fysonii*	Idukki, Malappuram, Palakkad, Thiruvananthapuram, Wayanad, Kollam (KL), Kas plateau (KL), Bhatkala (KA)	Madayipara, Kasaragod (KL)
21.	Eriocaulaceae	*Eriocaulon gopalakrishnanum*	Kotappara (KL)	Kotappara and Madayipara (KL)
22.	Eriocaulaceae	*Eriocaulon heterolepis*	Kasaragod, Malappuram (KL)	Bhatkal (KA)
23.	Eriocaulaceae	*Eriocaulon parviflorum*	Maharashtra, Kerala and Karnataka	Bhatkal (KA)

24.	Eriocaulaceae	*Eriocaulon odoratum*	Kas plateau (MH)	Bhatkal (KA)
25.	Eriocaulaceae	*Eriocaulon richardianum*	Kasaragod (KL), Goa and kas plateau (MH).	Bhatkal, Konaje (KA)
26.	Eriocaulaceae	*Eriocaulon lanceolatum* var. *lanceolatum*	Kas plateau (MH)	Mangalore (KA)
27.	Eriocaulaceae	*Eriocaulon lanceolatum* var. *bhatkalense*	Bhatkala (KA)	Bhatkal (KA)
28.	Eriocaulaceae	*Eriocaulon madayiparense*	Madayipara (KL)	Maniyampara and Madayipara (KL)
29.	Eriocaulaceae	*Eriocaulon robustobrownianum*	Kollam, Kannur, Wayanad (KL)	Hosangadi (KL)
30.	Eriocaulaceae	*Eriocaulon stellulatum*	Madayipara (KL), Kas plateau (MH)	Kumbla and Ananthapuram (KL), Konaje (KA)
31.	Euphorbiaceae	*Euphorbia katrajensis*	Satara (MH), Madayipara (KL)	Ananthapuram (KL)
32.	Euphorbiaceae	*Euphorbia notoptera*	Kolhapur (MH), Bhatkal, Shimoga, S. Kanara (KA)	Bhatakal (KA)
33.	Fabaceae	*Crotalaria filipes*	Kas plateau (MH), Honnavar plateaus (KA)	Bhatkal (KA)
34.	Fabaceae	*Geissapsis tenella*	South India	Kasaragod, Madayipara (KL) and Bhatkal (KA)
35.	Fabaceae	*Indigofera dalzellii*	Kas plateau (KA)	Bhatkal (KA)
36.	Gentianaceae	*Canscorinella bhatiana*	Kasaragod (KA) and Dakshina Kannada (KA)	Kasaragod, Madayipara (KL) and Bhatkal (KA)
37.	Gentianaceae	*Canscorinella stricta*	Mookambika wild life sanctuary	Valachil (KA)
38.	Gentianaceae	*Canscora pauciflora*	Wayanad, Malappuram, Kannur, Kozhikkode, Thrissur (KL)	Konaje (KA)
39.	Hydatellaceae	*Trithuria konkanensis*	South India	Udupi, Neerumarga (KA)
40.	Hydrocharitaceae	*Blyxa kasaragodensis*	Kasaragod (KL)	Kasaragod (KL)
41.	Hydrocharitaceae	*Blyxa mangalensis*	South India	Konaje (KA), Hosangadi (KL)
42.	Lamiaceae	*Pogostemon deccanensis*	Kasaragod, Muligadde, Madayipara (KL)	Kasaragod (KL)
43.	Lentibulariacea e	*Utricularia lazulina*	South India	Mangalore (KA)
44.	Lentibulariacea e	*Utricularia malabarica*	South India	Kasaragod-Mulleria (KL)
45.	Lentibulariacea e	*Utricularia cecilii*	South India	Kannur, Kasaragod, Bhatkal (KA)
46.	Lythraceae	*Rotala dhaneshiana*	Wayanad Wildlife Sanctuary (KL)	Kannur, Kasaragod (KL), Bhatkal (KA)
47.	Lythraceae	*Rotala baileyana*	Kasaragod (KL)	Kannur, Kasaragod (KL), Bhatkal (KA)
48.	Lythraceae	*Rotala kasaragodensis*	Kasaragod (KL)	Kannur, Kasaragod (KL), Bhatkal (KA)
49.	Lythraceae	*Rotala tulunadensis*	Permude	Seethangoli, Kasaragod (KL)
50.	Lythraceae	*Rotala malabarica*	Kannur	Maniyampara to

				Madayipara (KL)
51.	Lythraceae	*Rotala malampuzhensis*	South India	Kannur, Kasaragod, Konaje (KA)
52.	Melastomataceae	*Osbeckia muralis*	Kolhapur (MH), Kasaragod (KL)	Valahil (KA)
53.	Menynthaceae	*Nymphoides krishnakesara*	Madayipara	Madayipara (KL)
54.	Menynthaceae	*Nymphoides krishnakesara* var. *bispinosa*	Kasaragod (KL)	Kasaragod (KL)
55.	Orchidaceae	*Aerides crispa*	South India	Bhatkal (KA)
56.	Orchidaceae	*Bulbophyllum rosemarianum*	Idukki (KL)	Bhatkal (KA)
57.	Orobancaceae	*Parasopubia hofmanni*	Madayipara (KL)	Madayipara (KL), Koila (KA)
58.	Orobancaceae	*Parasopubia hofmannii* var. *albiflora*	Madayipara (KL)	Madayipara (KL), Koila (KA)
59.	Poaceae	*Apocopis mangalorensis*	Kasaragod, Idukki (KL),	Dakshina Kannada (KA)
60.	Poaceae	*Arthraxon meeboldii*	Idukki (KL)	Madayipara (KL), Bhatkal (KA)
61.	Poaceae	*Arundinella cannanorica*	Kas plateau (MH), Shimoga (KA), Iukki (KL)	Kasaragod (KL), Madayipara (KA)
62.	Poaceae	*Arundinella metzii*	Kasaragod, Malappuram, Kannur (KL)	Bhatkal (KA), Maniyampara and Madayipara (KL)
63.	Poaceae	*Bhidea burnsiana*	Kas Plateau (MH)	Maniyampara and Madayipara (KL)
64.	Poaceae	*Coelachne madayensis*	Madayipara (KL)	Madayipara (KL)
65.	Poaceae	*Coelachne minuta*	Kas Plateau (MH)	Maniyampara and Madayipara (KL), Bhatkal (KA)
66.	Poaceae	*Dichanthium panchganiense*	Kolhapur, Satara (MH), Bhatkal, Shimoga, S. Kanara (KA)	Madayipara (KL)
67.	Poaceae	*Dichanthium oliganthum*	Madayipara (KL), Kolhapur (MH)	Madayipara (KL)
68.	Poaceae	*Dichanthium paranjpyeanum*	Kas Plateau (MH)	Madayipara (KL)
69.	Poaceae	*Dimeria bialata*	Kannur, Wayanad (KL)	Madayipara (KL)
70.	Poaceae	*Dimeria deccanensis*	Idukki, Kozhikkode, Kannur, Pathanamthitta, Palakkad, Wayanad (KL)	Madayipara (KL)
71.	Poaceae	*Dimeria ornithopoda* var. *megalantha*	Kannur (KL)	Madayipara, Bandadka (KL)
72.	Poaceae	*Dimeria ornithopoda* var. *ornithopoda*	South India	Bandadka, Kotappara (KL)
73.	Poaceae	*Dimeria stapfiana*	South India	Madayipara, Kotappara (KL)
74.	Poaceae	*Garnotia arborum*	Satara (MH)	Madayipara (KL)

75.	Poaceae	*Glyphochloa acuminata*	Mysore (KA)	Maniyampara (KL)
76.	Poaceae	*Isachne bhatii*	Kalliad (KL)	Madayipara (KL), Bhatkal (KA)
77.	Poaceae	*Isachne veldcampii*	Madayipara (KL)	Dakshina Kannada (KA) and Kasaragod (KL)
78.	Poaceae	*Isachne swaminathanii*	Alappuzha, Kasaragod, Kannur, Malappuram, Kozhikkode and Kasaragod (KL).	Madayipara (KL)
79.	Poaceae	*Ischaemum cannanorensis*	Kannur (KL)	Kasaragod (KL)
80.	Poaceae	*Ischaemum copeanum*	Madayipara (KL)	Kannur (KL), Bhatkal (KA)
81.	Poaceae	*Ischaemum elimalayanum*	Ezhimala, Kannur (KL)	Madayipara (KL)
82.	Poaceae	*Ischaemum jayachandrani*	Kanuur (KL)	Madayipara (KL)
83.	Poaceae	*Ischaemum malabaricum*	Kanuur (KL)	Kasaragod (KL)
84.	Poaceae	*Ischaemum pappinisseriense*	Pappinisseri, Kanuur (KL)	Madayipara (KL)
85.	Poaceae	*Ischaemum raui*	Kasaragod, Idukki, Pathanamthitta, Kannur, Kollam, Thiruvananthapuram (KL)	Madayipara (KL)
86.	Poaceae	*Ischaemum yadavii*	Hassan, Bhatkala (KA), Kannur, Kasaragod and Kas plateau (KL).	Madayipara (KL), Bhatkala (KA)
87.	Poaceae	*Jansenella neglecta*	Kolhapur (MH)	Bhatkal (KA)
88.	Poaceae	*Nanooravia kayyurense*	Kasaragod (KL)	Maniyampara (KL)
89.	Poaceae	*Paspalum canarae*	Idukki, Thiruvananthapuram, Palakkad	Madayipara (KL)
90.	Poaceae	*Paspalum canarae* var. *fimbriatum*	Kannur, Wayanad	Madayipara (KL)
91.	Poaceae	*Spodiopogon rhizophorus*	Kannur, Thiruvananthapuram, Kozhikkode (KL)	Madayipara (KL)
92.	Rubiaceae	*Neanotis foetida*	Ratnagiri, Satara, Sindhudurg, Thane (MH)	Madayipara (KL), Konaje (KA)
93.	Rubiaceae	*Neanotis tubulosa*	Satara, Sindhudurg (MH), Idukki, Kannur, Kasaragod, Malappuram (KL), Nilgiri, Theni, Tirunelveli (TN)	Bhatkal (KA)
94.	Rubiaceae	*Spermacoce malabarica*	Kanuur (KL)	Koila (KA)
95.	Melastomataceae	*Osbeckia muralis*	Kannur, Thrissur, Wayanad (KL), Kolhapur (MH)	Valachil (KA)
96.	Zingiberaceae	*Curcuma oligantha* var. *oligantha*	Kannur (KL)	Madayipara (KL)

Table 3.8: List of notable rare and endemic species distribution in the study region. (KA-Karnataka, KL-Kerala, MH-Maharashtra)

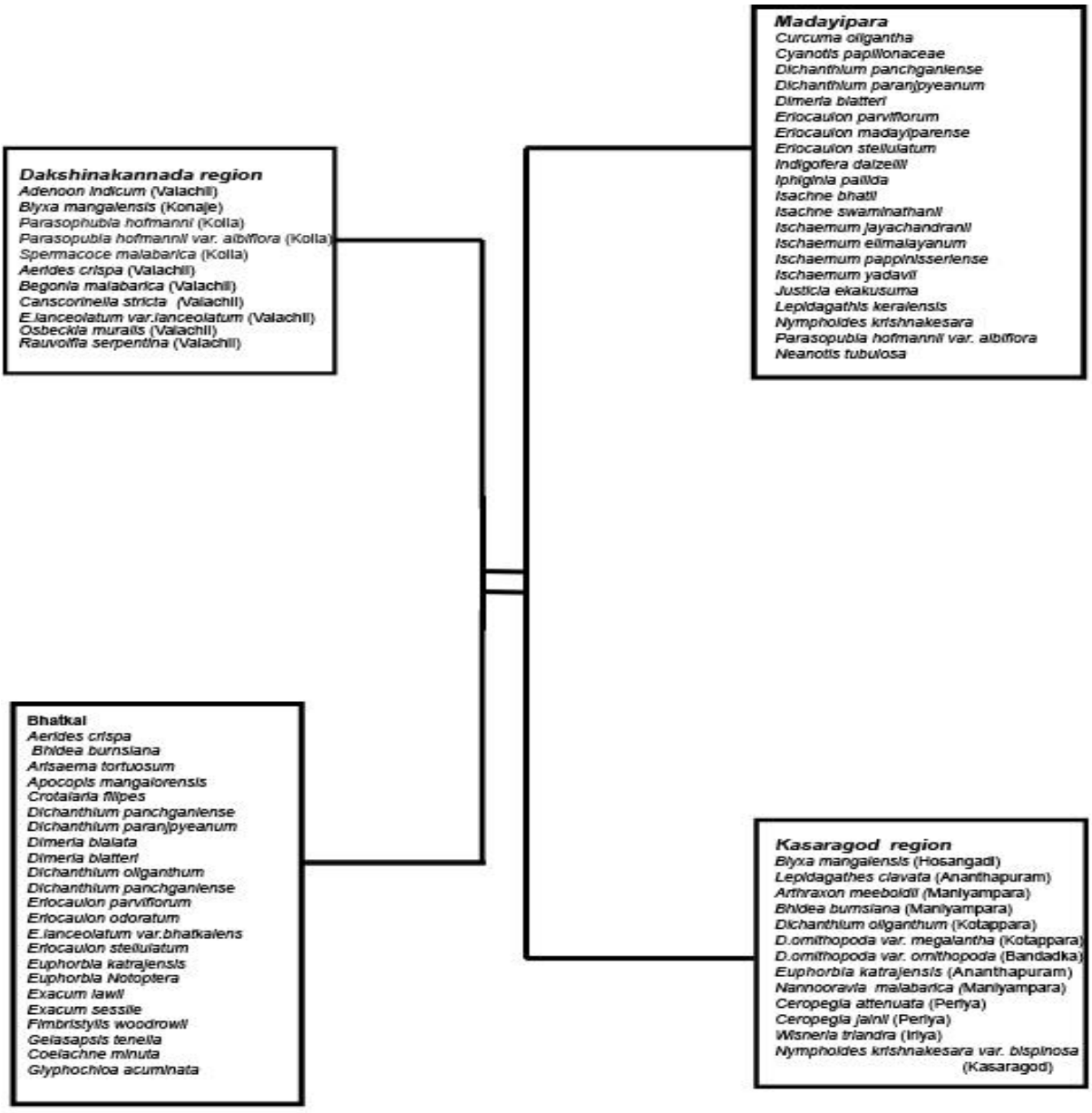


Figure 3.9: Important species representing the plateaus.

3.2.3: Orders and Families representing Endemic genera and species

Among the angiosperms, there is no family that is endemic to India. But, 49 genera are endemic to Indian political boundary and out of that, 44 are restricted to Peninsular India. Out of 44 endemic genera of Peninsular India, 36 are distributed along the Western Ghats. The family Poaceae has largest number of endemic species

(36 species), followed by Eriocaulaceae and Acanthaceae (Figure 3.10). *Eriocaulon* represented highest endemic species followed by *Rotala*, *Ischaemum* and *Dimeria* (Figure 3.11). Monocots dominates the endemic composition of the monsoon herbaceous flora (Table 3.9 & 3.10).

SL. No	Genus	Family	Total taxa	Distribution restricted
1	*Adenoon*	Asteraceae	1	WG
2	*Bhidea*	Poaceae	2	WG
4	*Glyphochloa*	Poaceae	5	Peninsular India

Table 3.9: List of endemic genera from study area.

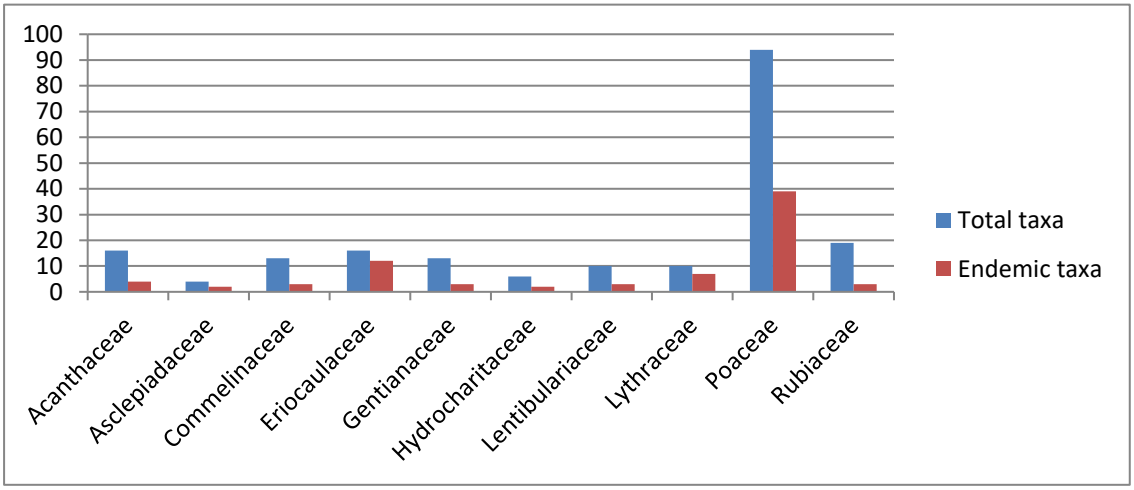


Figure 3.10: Families representing endemic herbaceous taxa in study area.

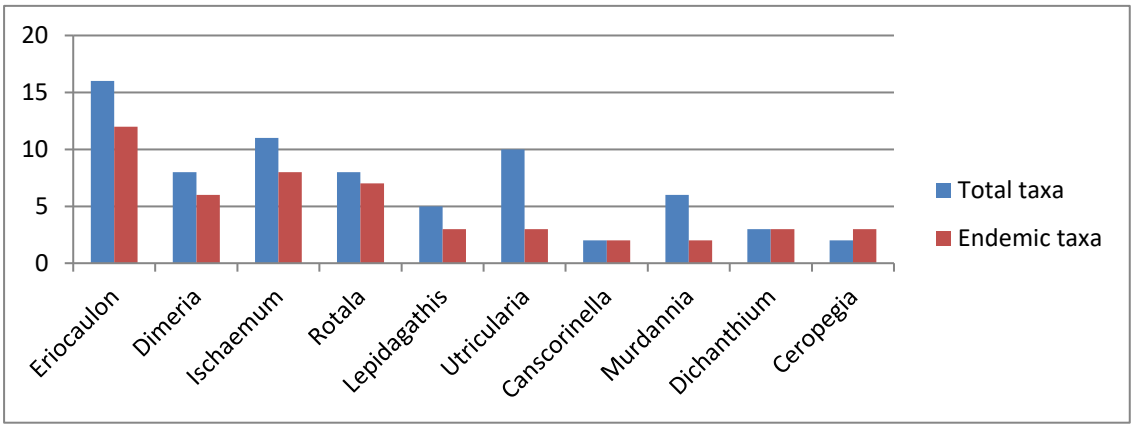


Figure 3.11: Top ten herbaceous endemic species rich genera from LRO's of study area.

Clade	Orders	Families	No of Genera	Total no. of taxa	Endemic taxa
Early angiosperms	Nymphales	2	2	5	3
Monocots	Alismatales	3	8	14	5
	Dioascoriales	1	1	1	0
	Liliales	1	2	3	0
	Asparagales	3	9	10	2
	Commenilales	1	3	13	3
	Zingiberales	1	1	1	1
	Poales	4	42	130	50
Eudicots	Fabales	4	14	28	2
	Rosales	1	2	2	0
	Cucurbitales	1	2	2	1
	Oxalidales	1	2	2	0
	Malpigiales	3	5	14	2
	Myrtales	3	5	13	8
	Sapindales	1	1	1	0
	Malvales	1	5	7	0
	Brassicales	1	1	1	0
	Caryophyllales	5	12	19	0
	Ericales	1	1	5	1
	Gentianales	4	13	37	9
	Boraginales	1	2	3	0
	Solanales	2	4	4	0
	Lamiales	7	30	52	8
	Asterales	1	20	23	1
	Apiales	1	1	1	0

Table 3.10: Orders in early angiosperms, monocots and eudicots representing taxa.

3.3.1: Microhabitats and species representation

We have categorised 9 macrohabitats each of these may have 1-5 types of microhabitats. The macrohabitats are I. Cryptogamic mat surfaces (three microhabitats), II. Vegetation of rock crevices (two microhabitats), III. Water pools (three microhabitats), III. Streams (two microhabitats), V. Soil filled depression (five microhabitats), VI. Large rock boulders (two microhabitats), VII. Wide and open Grassy hill slopes (one microhabitat), VIII. Forest covers and shrub patches-Associated to plateau region (two microhabitats), IX. Disturbed areas (two microhabitats) (Table 3.11a & 3.11b).

Cliff edges are absent in low-elevation grassland plateaus. Seasonal ponds and soil rich areas are of varying size and shapes. Because microhabitats are so closely related, two to three types of habitats frequently overlap. We have also noticed that microhabitat representations differ throughout plateaus that are near together. Each plateau has specific dominant microhabitat. Few species are restricted to specific microhabitats, whereas remaining species are shared by 2-6 types of microhabitats.

Macrohabitat	**Microhabitats**
I.Cryptogamic mat surfaces (CS)	I.a: Cryptogamic vegetation on flat/ small loose rock surfaces
	I.b: Cryptogamic vegetation on Large Rock Boulders (LB) with Highly exposed areas to sunlight
	I.c: Tree trunk surfaces
II. Vegetation of rock crevices (RC)	II.a: Small Rock crevices on exposed rock surfaces
	II.b: Rock crevices continuous channel like depth up to 10 cm
III.Water pools (WP)	III.a; Ephemeral temporary rock Pools
	III.b: Wide and deep Seasonal ponds (depth up to 1 meter or more)
	III.c: Shallow edges of ponds
IV.Streams (S)	IV.a: Vegetation of small seasonal water channels (Slow water flow)

	IV.b: Vegetation of long and deep seasonal water channels (Speedy water flow)
V.Soil filled areas (SFA)	V.a: Wide and open surfaces with varying soil depth
	V.b: Ephemeral Flush Vegetation (EFV)
	V.c: Rocky slopes filled with small soil depressions (RSD)
	V.d: Edges rocks and boulders
	V.e: Marshy areas
VI. Rock boulders (RB)	VI.a: Large Rock Boulders (LRB) with shady areas and small caves
	VI.b: Large rocky slopes and boulders in open areas (RS)
VII. Wide and open Grassy hill slopes (GS)	VII: Wide undulate areas
VIII. Forest covers and shrub patches	VIII.a: Shrubs and climber association inside the plateau
	VIII.b: Forest covers and associated flora (FCA)
IX. Disturbed areas	IX.a: Vegetation of Drainage channel
	IX.b: Weed affected areas (Construction/Dumping site/road side/plantation crops)

Table 3.11 a: Classification of Microhabitats.

Macrohabitat	**Microhabitats**	**Description**	**Study locations**
I.Cryptogamic mat surfaces (Exposed to direct sunlight). Rock surfaces and tree trunks provide low organic content with thermal variations and nutrients.	I.a: Cryptogamic vegetation on flat rock surfaces	Cyanobacterial colonies, lichens, and bryophytes cover the rock surfaces of relatively flat places, forming a pioneer layer. Thick mat-like formations are created by small ephemerals and mosses.	Valachil and Bhatkal
	I.b: Cryptogamic vegetation on small loose rocks	Uneven surfaces are exposed to direct sunlight. Lithophytes thrive in narrow openings in rock clusters, which also serve as hiding places for arthropods, mollusks, and annelids.	Maniyampara and Mudipu
	I.c: Cryptogamic vegetation on large Rock Boulders (LB) with highly exposed areas to sunlight	The moisture retention quality of these surfaces varies greatly depending on the length of the monsoon phase. *Ficus* spp. germinate readily in this microhabitat.	Valachil
	I.d: Tree trunk surfaces	Compared to large rock boulders the surface area of tree is less. But it retains moisture content for longer duration. The outer covering provides nutrients and suitable growing conditions for epiphytes and few ephemerals.	Seen in associated forest patches of all plateaus
II. Vegetation of rock crevices in varying width and length (RC): They are commonly found on lateritic plateaus with gaps, pockets, or fissures, where they provide a distinct biological niche for a restricted number of species.	II.a: Small Rock crevices on exposed rock surfaces (ERS)	Small pockets of soil or laterite gravels can be found on exposed rock surfaces. This location can only hold water for a few days during the monsoon season, and there is a little amount of soil deposits mixed with plant detritus. This situation aids the establishment of slow-growing perennials in the ecosystem.	Valachil
	II.b: Rock crevices continuous channel like (depth up to 10 cm).	They form rock channels on which thin stretch of soil accumulates. Continuous line formations are prominently visible from far place.	Valachil, Bandadka

III. Streams: Water streams or channels are originating from deep pools or ends with in it.	III.a: Slow water streams associated with ephemeral temporary rock pools with shallow depressions.	Slow water flow during heavy monsoon phase is common. Tufts of moss and algal colonies create space for growth of certain water loving plants. very less soil deposition is seen on these habitats.	Maniyampara
	III.b: Vegetation of long and deep seasonal water channels (Speedy water flow).	Due to continuous flow of water during monsoon phase much herbaceous flora have not been observed. These sites can provide water for various domestic purposes also. Also, few woody climbers are seen associated in the edges of these channels.	Adka
IV. Water pools: Monsoon temporary ponds come in a variety of sizes, occupying greater or smaller regions and containing some deposited soil. The size and shape of the pond are determined by geological and geographical variables, as well as the amount of rain that falls. Many invertebrates (odonata, crustacea, and other insects) and vertebrates (amphibians, wild animals) rely on these water sources, contributing to the habitat's biological value.	IV.a: Temporary rocky pools with depth and width up to 200 cm.	Continuous supply of water from surrounding areas makes the habitat available for water loving ephemerals. Negligible amount of soil accumulation is observed and surface of rocks can be seen easily.	Madayipara, Konaje, Bhatkal
	IV.b: Wide and deep seasonal ponds (depth up to 1 meter or more).	Ponds with deeper and larger expanses take longer to dry. Even after post monsoon season few ponds retain water. Pond with nearly one-meter depth or less represents great number of hydrophytes, which generally vary from free floating, fully submerged, emerging or rooted with floating leaves etc.	Konaje, Mukka-Surathkal, Madayipara, Maniyampara
	IV.c: Shallow edges of deep ponds.	Availability of soil is high and only up to 5-10 cm of water level is seen. The area provides enough space for aquatic plants because availability of sunlight is maximum. This habitat is an intermediate or a transition zone between soil rich areas/laterite rocky areas and water pools.	Konaje
V. Soil filled areas: On earlier observations made my Ollier and Sheath (2008) and Watve (2013), flat surfaces provide an ideal environment for the formation of soil and humus over the period. Lekhak and Yadav (2012) have defined this range under the terms Soil-Covered Areas (SCA) and SRA (Soil-Rich areas). Pramod and Pradeep	V.a: Wide and open surfaces with varying soil depth.	This habitat composition varies from place to place because soil accumulated over large areas for many years and covering the laterite plateau. The accumulation of humus and organic material nourishes the environment and harbours a diverse range of species, resulting in differences in species richness and composition across plateaus.	All region
	V.b: Ephemeral Flush Vegetation (EFV).	It develops on rocks where water seeps continually throughout the rainy season with little soil accumulation. This type of vegetation is common in small laterite gravel mixed areas.	Perla, Puttur

(2021) have defined this area as soil covered areas with varied thickness.	V.c: Small soil depressions on rocky slopes.	It is very characteristic for this kind of habitat with very less soil content on the surfaces. Temporary small streams with negligible amount of water flow also common here. Latex bearing plants are commonly seen in this habitat.	Ananthapuram
	V.d. Edges of rocks and boulders.	This region serves as a boarder for laterite formations and soil rich areas. The area also experiences heavy sunlight. Stunted growth of plants can be seen on the deep depressions, along the edges of the rocky plateaus, rock debris area.	Madayipara and Konaje
	V.e: Marshy areas	Water stagnant and marshy areas are common in low land areas of plateau. Only marsh loving plant groups occupy the area.	All region
VI. Large isolated rocks/Boulders (B)	VI.a: Large Rock Boulders (LRB) with shady areas and small cave like formations.	Sometimes tree covering on the top or luxurious growth of shrubs and creepers are seen over rock boulders. Since considerable amount of water is absorbed by these type of rocks, habitat specific species inhabited the area. Formation of small caves and fissures are unique to certain plateaus and thus support certain plant groups.	Maniyampara, Posadigumpe
	VI.b: Large rocky slopes.	Slant rocky surfaces are usually not able to retain moisture content or support stunted growth of plants. Because rock crevices and fissures in this area are nil.	Anathapura
VII. Wide and open Grassy hill slopes: Studies by Lekhak and Yadav (2012); Pramod and Pradeep (2021) have categorised this area under soil filled areas. But due to varied topographical factors we have considered this microhabitat seperatly.	VII: Wide and open Grassy hill slopes	Undulated or wavy formations of soil rich slant slopes with or without lateritic rocky formations provide a characteristic scenic beauty. Even appearance of trees and shrubs are limited. This area is considered as good grazing grounds.	Koila
VIII. Forest covers and shrub patches (Associated to plateau region)	VIII.a: Shrubs and climber association inside the plateau	The laterite hills have some characteristic woody perennial elements of slow growing trees and shrubs. This provides ambient space for perennating species, shade loving plants and medicinal plants.	Reported from all plateau regions.
	VIII.b: Forest covers and associated scrub jungles (FCA).	This area completely differs from other habitats because of the dominant tree species. Tree covers retain moisture content in the soil for long duration and provide conducive environment for shade loving plants.	Reported from all plateau regions.

IX. Disturbed areas	IX.a: Vegetation of drainage channel.	Drainage channels can harbour few species of grassland flora during rainy season. Seasonal flora can be supported by pure water flow.	Bhatkala and Maniyampara
	IX.b Weed affected areas.	Human disturbance like tourism, housing colonies, cashew plantations leads to introduction of many ruderal plants. Footpaths on most plateaus encourage the growth of invasive weeds that are not grazed by cattle, allowing them to spread over a broad area in a short period of time.	Reported from all plateau regions.

Table 3.11.b: Description of microhabitats.

The micro-habitat wise distribution of herbaceous plants and overall distribution of species in different habitats is given in Annexure I & Fig.3.12 resp. It shows that maximum number of herbaceous species are seen in soil rich areas, Rock crevices, temporary ponds and its shallow edges.

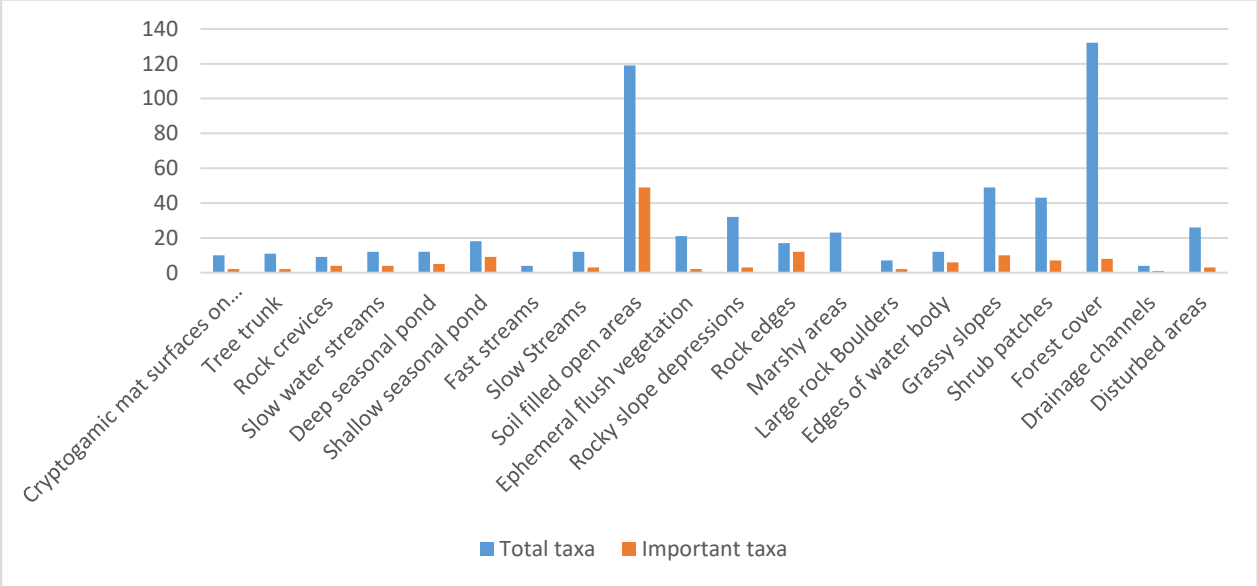


Figure 3.12: Over all distribution of species in different habitats.

Cryptogamic mat surfaces (CS): During the month of June-July, Algal colonies, crustose lichens, *Riccia* sp and Mosses are seen after the onset of monsoon. *Utricularia striatula*, *Garnotia arborum* are restricted to this type of microhabitats. *Hedyotis kurzii*, *Utricularia malabarica*, *Impatiens minor* gets associated with the habitat.

Vegetation of rock crevices (RC): *Bhidea burnsiana*, *Bhidea fischeri*, *Polycarpaea corymbosa* are exclusively seen in Small Rock crevices on exposed rock surfaces. *Polygala elongata*, *Neanotis foetida*, *Canscorinella stricta*, *Lepidagathis keralensis*, *Lepidagathis prostrata*, *Celosia spicata*, *Ophiuros bombaiensis*, *Burmannia coelestris*, *Crotalaria filipes*, *Crotalaria retusa*, *Derris scandens*, *Smithia conferta*, *Smithia salsuginea* preferably grow in channel like rock crevices containing soil depth up to 10 cm.

Water pools (WP): Ephemeral temporary rock Pools in shallow depressions are usually characterized by the presence of *Utricularia reticulata*, *Geissapsis cristata* and later *Ludwigia hyssapoides*, *Rotala malapuzhensis*, *Spodiopogon rhizophorus*, *Pycreus macrostachyos*, *Coelachne madayensis*. At the end of post monsoon phase

several Poaceae members occupy the area. *Blyxa mangalensis*, *Marsilea minuta* (aquatic fern), *Eriocaulon richardianum*, *Nymphoides indica*, *Crotalaria quinquefolia*, *Eriocaulon heterolepis*, *Oryza rufipogon*, *Wiesneria triandra*, *Utricularia aurea* etc. reported from wide and deep seasonal ponds in Konaje plateau. *Limnophila repens*, *Dopatrium junceum*, *Fimbristylis woodrowii* were reported from shallow edges of deep ponds. Recently reported *Blyxa mangalensis* and *Blyxa kasaragodensis* are distributed in these microhabitats of Dakshina Kannada and Kasaragod region.

Streams (S): In the beginning of monsoon ephemeral temporary rock pools with shallow depressions (Very slow water stream) provide conducive environment for short living plants. Isolated vegetation mats of *Eriocaulon richardianum*, *Rotala rotundifolia*, *Geissaspis cristata* also were formed in the middle of streams. During September-October water loving Cyperaceae and Poaceae members occupy the area. *Blyxa octandra* and 6 species of *Rotala* have been reported from 'Bedrampalla' pond and its associated streams in Maniyampara.

Soil filled areas (SFA): Wide and open surfaces with varying soil depth contains *Triumfetta rhomboidea*, *Naregamia alata*, *Mollugo pentaphylla*, *Rhamphicarpa fistulosa*, *Biophytum reinwardtii*, *Eriocaulon odoratum*, *Blumea malcolmii*, *Blumea membranacea*, *Kyllinga brevifolia*, *Ammannia baccifera*, *Nanooravia kayyurense*, *Polytrias indica*, *Eriocaulon cheemenianum* etc.

Ephemeral flush vegetation represented Linderniaceae members (*Lindernia crustacea*, *Lindernia ciliata*) from Konaje, Rubiaceae members (*Hedyotis cyanantha*, *Spemacoce articularis*) from Koila and Perla region. *Eriocaulon xeranthemum*, *Laportea aestuans*, *Pauzolzia zeylanica*, *Dicliptera paniculata*, *Senna occidentalis*, *Polycarpon prostratum*, *Drosera burmanni*, *Drosera indica* are reported from different study regions.

Rocky slopes filled with small soil depressions (RSD) are prominent in Ananthapura. *Lepidagathis clavata* is specifically restricted to this type of microhabitat.

Edges of laterite rocks are mainly occupied by *Pogostemon quadrifolius*, *Curcuma oligantha*, *Kyllinga nemoralis*, *Mitrasacme indica*, *Murdannia versicolor*, *Argyreia boseana*, *Evolvulus alsinoides*, *Evolvulus nummularius*, *Stylosanthes fruticosa*,

Justicia ekakusuma, *Justicia serpyllifolia*, *Eriocaulon stellulatum* etc. We could record 17 species restricted to this particular microhabitat.

Marshy areas and water stagnant areas are occupied by Cyperaceae, Lentibulariaceae, Balsaminaceae and Lamiaceae members. Maniyampara and Muligadde plateaus represent marsh loving *Cyperus* spp. Whereas; Bhatkal and Madayipara plateaus represent *Eriocaulon*'s. *Oxalis corniculata*, *Epaltes divaricata*, *Grangea maderaspatana*, *Coldenia procumbens*, *Heliotropium indicum*, *Heliotropium marifolium*, *Lindernia hyssopoides*, *Fimbristylis tenera*, *Fimbristylis tetragona*, *Utricularia aurea*, *Utricularia caerulea*, *Xyris indica*, *Xyris pauciflora*, *Pogostemon deccanensis* are specifically restricted to this type of microhabitat.

Rock boulders (RB): Dominant species in this habitat includes *Ariopsis peltata*, *Begonia crenata*, *Impatiens acaulis* etc. Rock boulders of Kumble is home to *Anisochilus* spp. *Hedyotis kurzii* and *Remusatia vivipara* also reported from Maniyampara.

Wide and open Grassy hill slopes (GS): *Heteropogon contortus*, *Heteropogon polystachyus*, *Heteropogon ritchiei*, *Spermacoce alata*, *Spermacoce articularis*, *Spermacoce lasiocarpa*, *Spermacoce malabarica*, *Spermacoce ocymoides*, *Spermacoce pusilla*, *Spermacoce remota*, *Spermacoce verticillata*, *Tricholepis glaberrima* are commonly seen in wide grassy slopes of Koila and Mudipu region.

Forest covers and shrub patches: The evergreen forest species like *Hydnocarpus pentandra*, *Holigrna arnottiana*, *Cinnamomum malabaricum*, *Ficus arnottiana*, *Ficus benghalensis*, *Ziziphus oenoplia*, *Ziziphus rugosa* are common in Madayipara. Thick clumps of *Getonia flouribunda*, *Careya arborea*, *Syzigium* spp, *Sapium insigne*, *Strychnos nux-vomica*, *Zizyphus mauritiana*, *Grewia micrococcos*, *Flacourtia montana*, *Memecylon edule*, *Aglaia eleagnoidea*, *Hugonia mystax*, *Bridelia retusa*, *Benkara malabarica* are seen in various study region. Climbers, creepers, epiphytes and parasites also make a remarkable appearance in this habitat altogether giving mini forest patches in the plateaus. Details of shrubs and tree species distributed in the study region is given in Annexure II.

The families with the largest representation were Moraceae, Rubiaceae (5 species each), Fabaceae, Asteraceae, Euphorbiaceae (4 species each), Anacardiaceae, Fabaceae, Tiliaceae, Rhamnaceae (3 species each) and Acanthaceae, Combretaceae,

Convolvulaceae, Clusiaceae, Araceae, Lamiaceae, Lauraceae, Malvaceae, Melastomataceae (2 species each). The remaining families were represented by single species each. Euphorbiaceae represented a greater number of shrubs, Moraceae showed a greater number of trees, Convolvulaceae showed a greater number of creepers (Figure. 3.13).

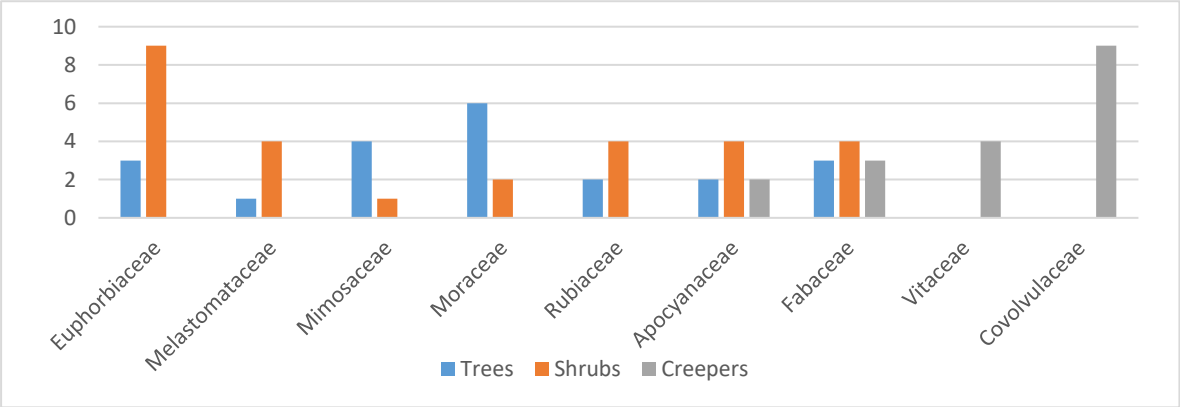


Figure 3.13: Richness of families in tree, creepers and shrub species (families with 4 or more species shown).

Disturbed areas (DA): *Spigelia anthelmia*, *Gomphrena celosioides*, *Celosia argentea*, *Cassia tora* had the strongest impacts on both species' diversity and composition. In the same way, weeds like *Tridax procumbens*, *Acanthospermum hispidum* dominates the disturbed grasslands and road edges. Family Asteraceae (5 species) contribute major invasive flora to this ecosystem followed by Euphorbiaceae (3sp), Amaranthaceae (2sp) (Table 3.12). Nearly 17 invasive are identified as major infestants in the study regions. *Monochoria vaginalis* and *Blyxa aubertii* are common in drainage channels.

SL. No	Species name	Family	Affected endemic species	Study location
1.	*Acalypha indica*	Euphorbiaceae	*Eriocaulon gopalakrishnanum*	Kotappara
2.	*Acanthospermum hispidum*	Asteraceae	*Utricularia lazulina*	Konaje, Periya
3.	*Alternanthera sessilis*	Amaranthaceae	*Nanooravia malabarica*	Maniyampara
4.	*Calyptocarpus viralis*	Asteraceae	*Eriocaulon eurypeplon*, *Eriocaulon cheemenianum*	Mujungav
5.	*Celosia argentea*	Amaranthaceae	*Utricularia lazulina*	Bhatkal

6.	*Cleome viscosa*	Capparidaceae	*Burmannia pusilla*	Konaje, Kumbla, Perla
7.	*Euphorbia hirta*	Euphorbiaceae	*Geissapsis tenella*	Bhatkal
8.	*Gomphrena celosioides*	Amaranthaceae	*Eriocaulon lanceolatum* var. *bhatkalense*	Bhatkal
9.	*Leucas linifolia*	Lamiaceae	*Rauvolfia serpentina*	Valachil
10.	*Micrococca mercurialis*	Euphorbiaceae	*Iphiginia indica*	Konaje, Kateel
11.	*Senna tora*	Fabaceae	*Canscorinella stricta*	Valachil
12.	*Spigelia anthelmia*	Loganiaceae	*Neanotis foetida*	Bandadka, Konaje
13.	*Sida acuta*	Malvaceae	*Eriocaulon eurypeplon*	Bhatkala, Kommangala
14.	*Tridax procumbens*	Asteraceae	*Utricularia malabarica*	Konaje, Mudipu
15.	*Pennisetum polystachion*	Poaceae	*Euphorbia katrajensis*	Maniyampara, Ananthapuram
16.	*Sphagneticola trilobata*	Asteraceae	*Eriocaulon eurypeplon, Canscorinella bhatiana*	Ananthapuram
17.	*Synedrella nodiflora*	Asteraceae	*Utricularia malabarica*	Madayipara, Kotappara

Table 3.12: Details about weed species which has affected endemic flora.

3.3.2: The similarity index

The similarity index between these communities varied from 0-0.50. 24 combinations were possible when 9 communities were compared between each other for their similarity in species composition, but interestingly only 2 microhabitats were found to have more than 50% similarity which clearly indicates the diversity of habitats in grassland plateaus. On the other hand, few microhabitats found 100% dissimilar. Temporary pools (TMP) and cryptogamic vegetation on rock surfaces were found to be the two communities, which show more dissimilarity with remaining communities. (Table 3.13).

	CS	S	RC	LRB	GS	SFA	WP	RS	DA
CS		0[b]	0.04	0.03	0[b]	0[b]	0[b]	0[b]	0[b]
S			0[b]	0[b]	0[b]	0.065	0.55	0[b]	0[b]
RC				0.60	0.30	0.53	0[b]	0.28	0.06
LRB					0.03	0.046	0[b]	0.43	0[b]
GS						0.48	0[b]	0.04	0.12
SFA							0.03	0.20	0.23
WP								0[b]	0[b]
RS									0.25
DA									

Table 3.13: Similarity index value between microhabitats of study region. **Note:** [a]Microhabitats having more than 50% similarity; [b]Microhabitats which are 100% dissimilar.

3.3.3: Diversity indices

The Shannon diversity index (H) ranges from 2.10 to 3.68 (Table 3.14). The highest Shannon diversity index was recorded in Soil Rich Areas (3.68) followed by Rock crevices (3.55) and temporary water pool (2.66). The Simpson index of dominance ranged from 0.0328 to 0.1738. The highest Simpson index was recorded in soil filled areas (0.1738) followed by temporary water pool (0.1616), Rock Boulders (0.1306) and Streams (0.1286).

The species richness index in different microhabitat of study area ranged from 0.0776 to 0.3372. The highest species richness index (R) was recorded in Soil Rich Areas (0.3372) followed by Rock crevices (0.1457) and Grassy slopes (0.1489). Disturbed area also represented Shannon Index (2.98), Simpson Index (0.0967), Species Richness Index (0.1356).

Microhabitat	**No. of species**	**Shannon Index**	**Simpson Index**	**Species Richness Index**
RC	46	3.55	0.0482	0.1457
S	14	2.26	0.1286	0.0776
CS	11	2.17	0.0971	0.0808
WP	17	2.66	0.1616	0.1017
GS	36	3.54	0.0478	0.1489

SFA	70	3.68	0.1738	0.3372
LRB	9	2.10	0.1306	0.0747
RS	12	2.12	0.1245	0.0866
DA	22	2.98	0.0679	0.1356

Table 3.14: Species Number, Shannon Diversity Index (H), Simpson Index (C) and Species Richness Index (R) of different microhabitats in selected study region.

3.3.4: Overall microhabitat representation

Each grassland plateaus are different in their microhabitat representation. These can vary in size, shapes and species composition based on geographical conditions, intensity of rainfall, topography and various other ecological factors. In each study region 3-4 types of microhabitats are dominantly seen when compared to other types. For example, one part of Bhatkal represents rocky hills with negligible amount of soil, whereas another part consists of plain lands with deep soil filled areas**.** Small rock crevices and cryptogamic vegetation is also observed. However, deep-water pools or streams are rarely seen.

Kateel and Mukka region shows soil rich areas mixed with patches of forest cover. Konaje, Neerumarga and Mudipu plateaus are characteristic with seasonal ponds with good number of endemic species. Rock crevices, different types of soil-filled areas, shrub patches and forest covers are common. Valachil plateau consist of rocky boulders and soil rich areas in edges of rocks. Koila plateau is known for its undulated and wavy stretches of grassy slopes with negligible amount of lateritic content in the soil. Plateau stretches of Kasaragod district share similar habitats with unique representation of *Strychnos* forest patches and laterite rich grasslands. Anathapuram plateau shows slant rocky plateau stretches, which provide unique ecological niche for distinct species composition. Posadigumpe consist of lateritic hillock region intermingled with forest patches and shrubs. Kommangala plateau is made up of wide and plain laterite stretches with abundant rock crevices with less soil in it. Kotappara and Bandadka share similar kind of habitats with a kind of rich ephemeral flush vegetation and rock crevices. Perla and Puttur region also share similar kind of habitats. Madayipara Plateau shows all types of habitats over a very large stretch (nearly 600 acres) of the grassland area.

3.3.5: Soil analysis

PH varied from 6.2-6.8 and E.C showed values ranging from 0.2-1.4. A detailed soil analysis in species rich microhabitat regions of present study is given in (Table 3.15). Soil varied from sandy-to-sandy loam type with good water holding capacity and normal EC. It was highly acidic (4.5–6), rich in organic carbon, available nitrogen and available potassium.

Parameters	**TMP**	**ERB**	**CE**	**EFV**	**SFD**	**CR**	**RC**	**FCA**	**GS**
PH	5.59±0.2	6.38±0.2	6.5±0.2	4.8±0.1	6.5±0.3	6.4±0.2	6.3±0.3	5.8±0.2	5.9±0.2
	medium acidic	Slightly acidic	Slightly acidic	highly acidic	Slightly acidic	Slightly acidic	Slightly acidic	medium acidic	medium acidic
EC (dsm^{-1})	0.29±1	0.7±0.2	1.2±0.3	1±0.4	0.28±0.2	1.4±.4	1.1±0.3	0.99±0.3	0.6±0.3
	Average	average	average	average	average	average	Average	Average	Average
%OC	4.23±0.4	4.2±0.4	6.2±0.3	5.1±0.4	4.28±0.2	7.4±0.4	6.1±0.3	5.5±0.5	1.5±0.4
	Very high	very high	Very high	Very high	Very high	Very high	Very high	Very high	Very high
AN (Kg/ha)	>700	>700	>700	>700	>700	>700	>700	>700	>700
	very high	very high	very high	very high	very high	very high	very high	very high	very high
AP	25.7±1	27±0.6	23±2.2	28±0.9	221±1	23.3±5	22.7±3	23±0.8	27±1
	Very high	less	Less	less	Medium	less	Less	Less	Less
AK	562.6±2	591±6	464.2±2	106±39	200±44	388.8±39	269.7±57	389.3±34	376±2
	very high	very high	very high	very high	medium	high	medium	High	High
Sand %	59.8	50.63	55.83	77.78	48.4	89.07	64.39	66.76	76.78
Silt %	48.37	27.9	24.05	25.74	28.46	6.85	17.82	25.98	17.68
Clay %	11.72	15.5	17.17	19.53	20.89	6.02	7.88	15.27	18.5
Soil type	Loam	sandy loam	sandy loam	sandy loam	loam	sandy	sandy loam	sandy loam	sandy loam
Water holding capacity (WHC)	66.72	64.36	124.98	52.69	88.31	32.85	59.31	61.4	86
Density (g/cc)	2.15	1.49	1.08	1.67	1.44	1.94	1.81	1.65	1.48
Porosity %	54.04	63.8	48.98	53.9	67.2	54.8	56.34	64.57	58.21

Table 3.15: Soil properties of different habitats.

EC: Electrical conductivity, OC: Organic carbon, WHC: Water holding capacity L: Less, SA: Slightly Acidic, H: High, VH: Very High, A: Adequate, A N-Available Nitrogen, A P- Available Phosphor, A K-Available Potassium, A S-Available Sulphur, A Z-Available Zink, A B-Available Boron, A Fe-Available Iron, A MN-Available Manganese.

3.3.6: Rare and Endemic species distribution with reference to microhabitats

Soil filled areas and Rock crevices filled with soil have shared maximum number (29) of endemics followed by Soil filled areas alone (15) (Table 3.16). Cryptogamic mat surfaces provide space for *Utricularia malabarica* and *Garnotia arborum*. Hardy perennial herbs like *Lepidagathis keralensis*, *Lepidagathis prostrata* persist in flat rocks with crevices. *Canscorinella stricta* was restricted to this microhabitat of Valachil. *Eriocaulon fysonii*, *Rotala malampuzhensis*, *Danthonidium gammiei*, *Wiesneria triandra*. *Nymphoides krishnakesara*, *Blyxa mangalensis*, *Blyxa kasaragodensis*, *Isachaemum mangaloricum*, *Eriocaulon cuspidatum*, *Eriocaulon heterolepis*, *Rotala kasaragodensis*, *Rotala macrandra*, *Rotala malabarica*, *Rotala malampuzhensis*, *Rotala tulunadensis*, *Geissapsis tenella*, *Coelachne madayensis* were reported from Water pools, streams or from their associated edges. *Justicia ekakusuma*, *Eriocaulon cheemenianum*, *Eriocaulon odoratum*, *Eriocaulon gopalakrishnanum*, *Eriocaulon lanceolatum*, *Eriocaulon lanceolatum* var. *bhatkalense*, *Eriocaulon stellulatum*, *Pogostemon deccanensis*, *Utricularia lazulina*, *Paspalum canarae*, *Curcuma oligantha* are notable endemic species reported from microhabitats of soil filled areas. *Begonia malabarica* was reported from rock boulders of Kumbla. Wide and open Grassy hill slopes of Koila was home for *Spermacoce malabarica*, *Parasopubia hofmanni* and *Parasopubia hofmannii* var. *albiflora*. *Ixora brachiata*, *Salacia fruiticosa* and *Memycelon malabaricum* are commonly seen in shrub patches of Konaje plateau. In some highly disturbed habitats, such as abandoned mines and near housing colonies native species find hard to establish. However, 17 endemics are reported (Table.3.12).

I	2							
II	0	8						
III	0	0	9					
IV	0	0	5	6				
V	1	29	2	3	15			
VI	0	2	0	1	7	1		
VII	0	6	0	0	4	2	0	
VIII	0	1	0	0	7	0	0	0
IX	0	0	0	0	1	0	0	0	17
	I	II	III	IV	V	VI	VII	VIII	IX

Table 3.16: Distribution of herbaceous endemics in different microhabitats.

3.4.1: Mat-forming and mass flowering plants

Mat-forming plants are low growing plants that vigorously trail along soil or water surfaces and spread out to produce a mat like cover. Mass flowering plants are of the same stock flower at the same time, or with creeping stolon's (Figure 3.14). Important mat forming and mass flowering genera during seasonal succession stages are given in Figure 3.15.

Species name: *Nanooravia kayyurense*
Family: Poaceae
Study location: Maniyampara (2.4387° N 75.2012° E)
- During the end of heavy monsoon phase few prominant patches of this particular species is observed from very far place.

Species name: *Dimeria hohenackeri* & *Eragrostis indica*
Family: Poaceae
Study location: Bhatkala (14.0186 N 74.56985 E)
- During post monsoon phase all grassland plateaus are characterised with mat formations of graminiodes.

Species name: *Lepidagathis prostrata*
Family: Acanthaceae
Study location: Konaje (12.8170° N 74.9231° E)
- During dry phase patches of this drought enduring species seen in heavy blooming with pink or white flowers which attract large number of honey bees and Carpenter bees.

Species name: *Smithia conferta*
Family: Fabaceae
Study location: Bandadka (12.4387° N 75.2012° E)
- Plain grassland plateau of the study location is charaterised with appearance of lumpy-bumpy green patches of *Smithia* with yellow flowers during Aug-Sept.

Species name: *Exacum bicolor*
Family:Schrophulariaceae
Study location: Permude (12.4387° N 75.2012° E)
- This plant has considerable hight among herbaceous flora in the study region. Also clusters of white flowers with purple blotches are very significant during the end of September.

Species name: *Eragrostis indica*
Family: *Poaecae*
Study location: All study regions.
- This grass has very luxurious growth from the beginning of Augsut and fruiting season end with post monsoon phase. Thick *Eragrostis* patches with brown-to purple inflorescens are very prominently seen in all study regions.

Species name: *Murdannia Semipteres*
Family: Murdanniaceae
Study location: Madaippara(12.0323° N 75.2567° E)
Type of habitat: Edges of temporary water pools.
- Grows luxuriously & clusters of plants shows high peak in flowering between July and August. Small flowers create pale violet patches all over the plateaus which can be easily recognised from a long distance.

Species name: *Eriocaulon eurypeplon*
Family: Eriocaulaceae
Study location: Maniyampara (12.4387° N 75.2012° E)
Type of habitat: Soil filled depressions
- This species grows abundantly (jul.-sept.) in the study location. Small white tops create illusion of white waves on the landscape.

Species name: *Alysicarpus bupleurifolius*
Family: Fabaceae
Study location: Madaippara (12.0323° N 75.2567° E)
Type of habitat: Soil filled areas
- This species seen flowering during sept-oct. Orange and pink mixed flowers are very clearly seen in clusters from a distance all over the study region.

Species name: *Ericaulon gopalakrisnhanum*
Family: Eriocaulaceae
Study location: Kotappara(12.3059° N 75.0947° E)
Significance: Ephimeral flush vegetation on soil filled plain plateau.
This species grows luxuriously in the habitate. Clusters of plants shows high peak in flowering during August. Appears like white mat from considerable distance.

Species name: *Utricularia purpurascens*
Family: Lentibulariaceae
Study location: Konaje(12.8170° N 74.9231° E)
Significance: Ephimeral flush vegetation on soil filled areas.
This species is distributed in most of the study regions. From June end to mid August, fields appear like blue blanket covered over green landscape.

Species name: *Neanotis foetida*. **Family:** Rubiaceae
Study location: Konaje(12.8170° N 74.9231° E)
Significance: Ephimeral flush vegetation on soil filled areas and small rock crevises.
This plant has very short life span and its presence is felt through mild malodorous smell. The species seen spread over laterite crevises showing a combination of pink flowers over black rocks in mid June.

Figure 3.14: Mat forming and Mass flowering species from different study areas and their characteristic features.

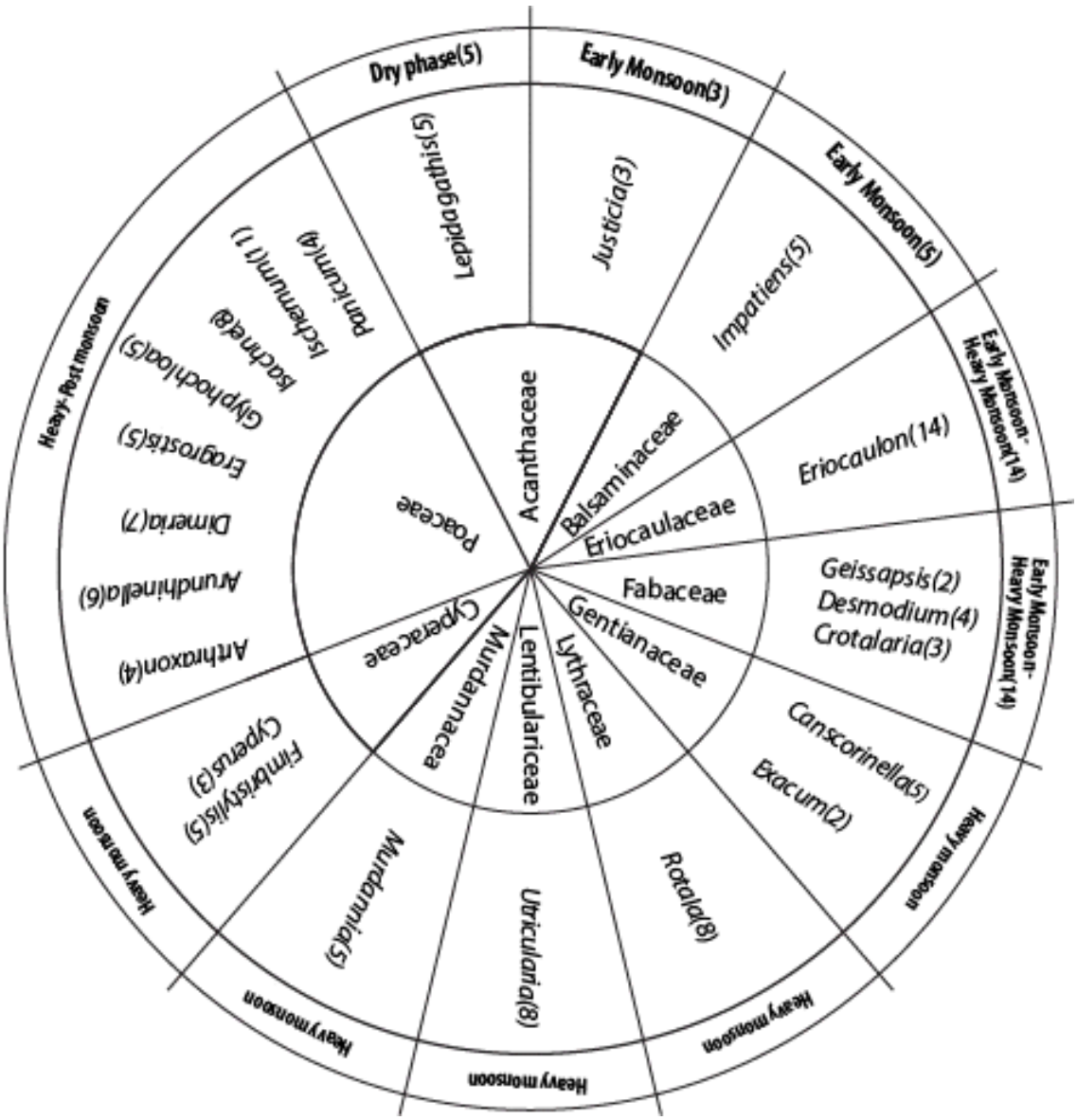


Figure 3.15: Important mat forming genera during seasonal succession stages.

3.5.1: Plant adaptations

Adaptations are characteristics that allow a species to thrive in a certain environment. Different sorts of root and stem modifications, thin leaves to absorb water without losing moisture owing to evaporation, and vividly coloured flowers are all examples of grassland plant adaptations. Plants in grasslands, particularly grasses, grow from their roots rather than their tips. This allows them to withstand grassland fires, which are common in the dry, hot climate. The majority of them are annuals, meaning they finish their life cycle in a short period of time.

Eight major adaptations seen in the study region:

1. Carnivory: Carnivorous plants include *Drosera indica* (common in all plateaus), *Drosera burmanii* (less common), and *Utricularia* species (bladderworts—abundance varies by plateau). During the season, their growth ensures that the root bladders and tentacles of plants receive an adequate supply of small insects or larvae. Because these plants grow in soil that is typically thin and deficient in nutrients, they rely on insects to meet their nutrient needs.

2. Succulence: Following heavy rains, many succulent plants of Commelinaceae and Euphorbiaceae dominate the barren rocky areas with little soil depositions. Most of the *Cyanotis*, *Euphorbia* species represent this nature by adapting through spiny leaves or with latex content.

3. Poikilohydry: *Lepidagathis* spp and *Blumea oxydonta* can tolerate high temperature and extreme conditions. Water content varies with the varying humidity in the environment in these plants. The ability to tolerate desiccation is primarily a protoplasmic property (Gaff, 1980).

4. Subterranean perennating organs: Corms, rhizomes, bulbs and tuber forms are seen as part of adaptive traits to overcome the drought challenges in the grassland plateaus. Geophytes like *Ceropegia* spp, *Habenaria* spp., *Iphigenia* spp., *Curcuma* sp, *Asparagus* sp, *Gloriosa* sp fall in this category. These plants can withstand hot summer days and complete their flowering and fruiting cycle during monsoon season and survive the dry season in the form of underground storage organs.

5. Hydrophytes: Monsoon seasonal ponds are integral part of grassland plateaus that exhibits unique plant adaptations to survive in the aquatic conditions. For example, the outer stem tissues of *Crotalaria quinquifolia* and *Geissapsis* spp appears like a spongy covering to adjust with the aquatic system. Submerged plants like *Eriocaulon* spp or *Blyxa* spp usually crowded in the areas where the amount of available sunlight is maximum.

6. Parasitism: Complete parasitism exhibited by *Cuscuta* sp on shrubs or trees and root parasitism by *Striga* spp on *Lepidagathis prostrata*. *Ramphicarpa fistulosa*, *Parasopubia hofmanni* are commonly seen facultative hemi-parasitic plants.

7. Vegetative propagation: Vegetative propagules such as bulbs and bulbils formed at the leaf tips are an adaptation of some plants of plateaus (Krieger et al., 2003). For example, *Curculigo orchioides* develop such propagules that ensure high reproductive success in these habitats**.**

8. Production of seeds: Many annual plants like *Eriocaulon*'s, *Rotala*'s and *Utricularia*'s produce great quantities of smaller seeds. This helps to ensure at least a few will end in a favourable place for growth. Weeds have a high survival rate because they produce a large number of seeds and have good dispersal ability.

3.5.2: Life forms

An analysis on the life-form reveals that nearly 56.5 % of the species recorded were Therophytes, followed by Phanerophytes (19.72 %), Chaemephytes (5.56%), Hemicryptophytes (4.66 %) and Cryptophytes (5.56 %) (Figure 3.16). Terrestrial habitat supports 95% of angiosperms recorded from the study area. The dominance of therophytes is possibly due to their greater ability to survive under disadvantageous environmental conditions (Porembski, 2006). Due to their short life-cycle and high reproduction rate, they are well-adapted to extreme environments and high levels of disturbances. They survive the dry spell as dormant seeds in the soil seed bank. Therophytes may face high risk of mortality if rain fails or if rainy season followed by a drought, as these species are highly susceptible to drought without specific adaptations.

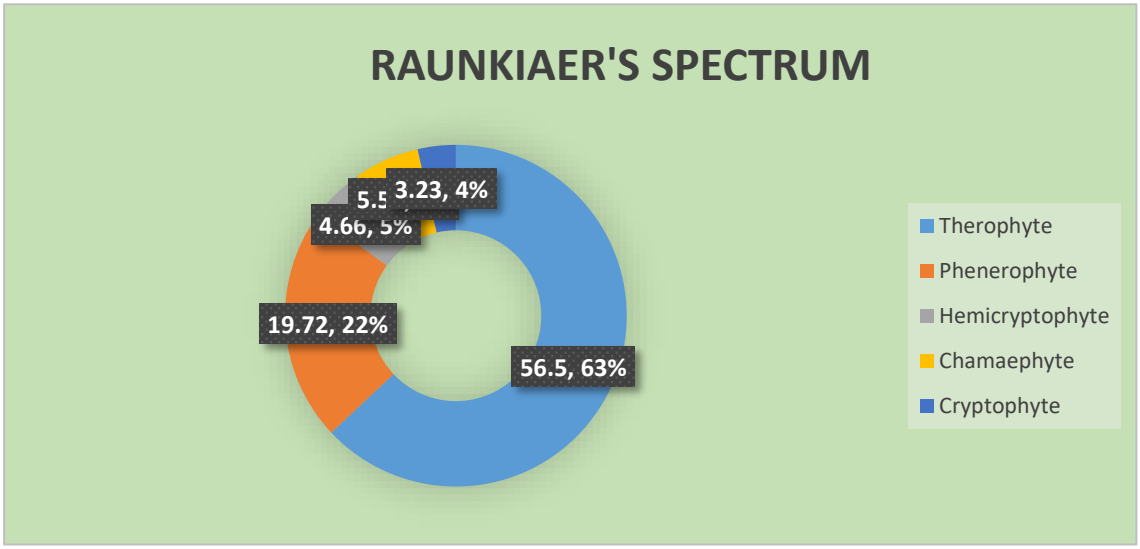


Figure 3.16: Raunkiaer's spectrum-life forms.

4.Phenological variation in selected plants of permanent plot study

4.1.1: Trends in Temperature and rainfall in Konaje plateau: The air temperature in the study region displayed two distinct patterns of changes with time. From 2012 to 2017, T mean, T min, T max all fluctuated with time without apparent trends. from 2012 temperature indices increased at the rate of 0.048˚C (R^2=0.40, P<0.05), 0.074˚C (R^2=0.54, P<0.05), and 0.074˚C (R^2=0.54, P<0.05) per annum, corresponding to the total changes of 1.5,2.0 and 1.0 ˚C for the period. The highest rainfall is experienced during the June-August months with humidity ranging from 70-90 (Fig. 4.1 A & 4.1 B).

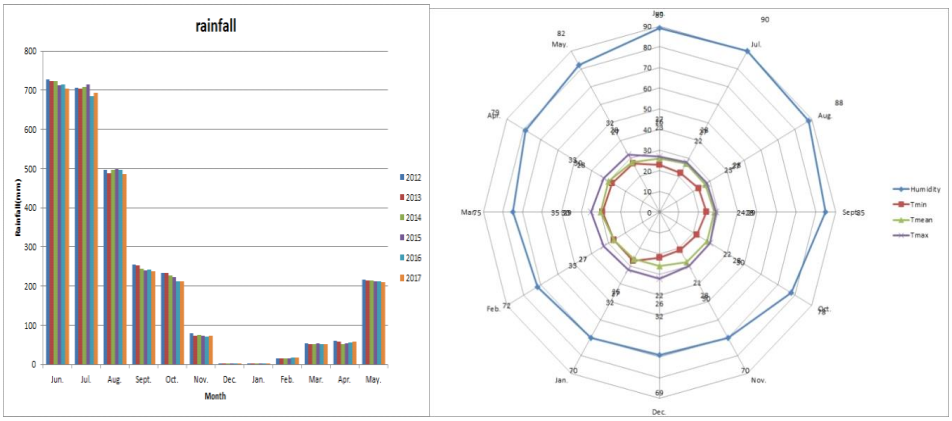


Figure 4.1A & 4.1B. Rainfall, Temperature and Humidity of the study region.

4.2.2: Overall flowering phenology

Depending upon the vegetative and reproductive phenology of plants, few studies have highlighted different characteristics phases of plateaus. The ephemeral plant communities are mainly of three types i.e. forbs without storage organ (geophytes), forbs with storage organ and graminiodes (Poaceae and Cyperaceae) in the present work. Overall abundance of forbs without storage organs are more. It is then followed by Graminiodes and forbs with underground storage organs Figure 4.2.

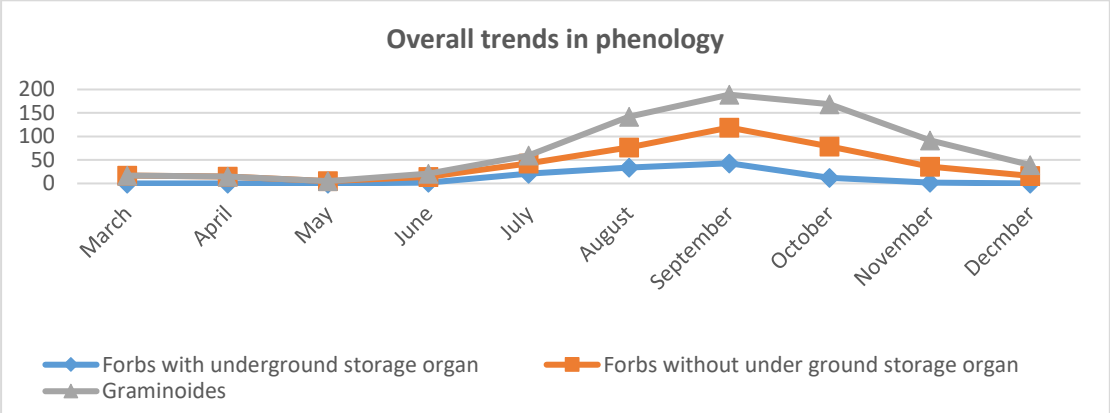


Figure 4.2: Phenology in different herbaceous plant communities.

Reproductive phenology of 26 species (Table 4.1) showed that generally 80% of the species start vegetative phase in middle of June – July end and remaining species germinate at the beginning of September. While 65.4% species flower during July end to august end.70% of the species start fruiting at the beginning of September. In the first year of study, 2012–13, 40.8% of the species showed flowering in September followed by 39.9% in August, although 19.3% of the species showed flowering in October and November. The year 2012–13 showed highest flowering (55.38%) in August followed by (45.2%) in September. Vegetative, Flowering and fruiting phenological pattern of herbaceous plants are shown in Fig.4.3 – fig 4.4.

Sl No.	Species name	Species-abbreviation	Family
1.	*Sopubia delpinifolia*	Sop-delp	Schrophulariaceae
2.	*Murdannia semepteris*	Mur-sem	Murdanniaceae
3.	*Eriocaulon eurypeplon*	Erio-eury	Eriocaulaceae
4.	*Jansenella griffithiana*	Jans-grif	Poaceae
5.	*Lepidagathis prostrata*	Lep-pros	Acanthaceae
6.	*Utricularia reticulata*	Utr-ret	Lentibulariaceae
7.	*Lindernia ciliata*	Lind-cil	Schrophulariaceae
8.	*Drosera indica*	Dros-ind	Droseraceae
9.	*Cyanotis cristata*	Cya-crist	Commelinaceae
10.	*Dimeria hohenackeri*	Dim-hohn	Poaceae
11.	*Ramphicarpa longifolia*	Rhm-long	Orobanchaceae
12.	*Canscora paucifolia*	Can-pauz	Gentianaceae
13.	*Rotala malabarica*	Rot-malm	Lythraceae
14.	*Eriocaulon cheemenianum*	Erio-chem	Eriocaulaceae
15.	*Ischemum indicum*	Isha-Ind	Poaceae
16.	*Burmannia pusilla*	Burm-pus	Burmanniaceae
17.	*Blumea oxydonta*	Blum-oxy	Asteraceae
18.	*Utricularia purpurea*	Utr-purp	Lentibulariaceae
19.	*Polycarpea corymbosa*	Poly-corym	Lythraceae
20.	*Neanotis foetida*	Neo-foet	Rubiaceae
21.	*Alysicarpus bupleurifolius*	Aly-bup	Fabaceae

22.	*Justicia procumbens*	Just-proc	Acanthaceae
23.	*Arundinella metzii*	Aru-metz	Poaceae
24.	*Polygala elongata*	Pol-elon	Polygalaceae
25.	*Utricularia uliginosa*	Utr-ulig	Lentibulariaceae
26.	*Glyphochloa acuminata*	Gly-acum	Poaceae

Table 4.1: Plants selected for phenological studies.

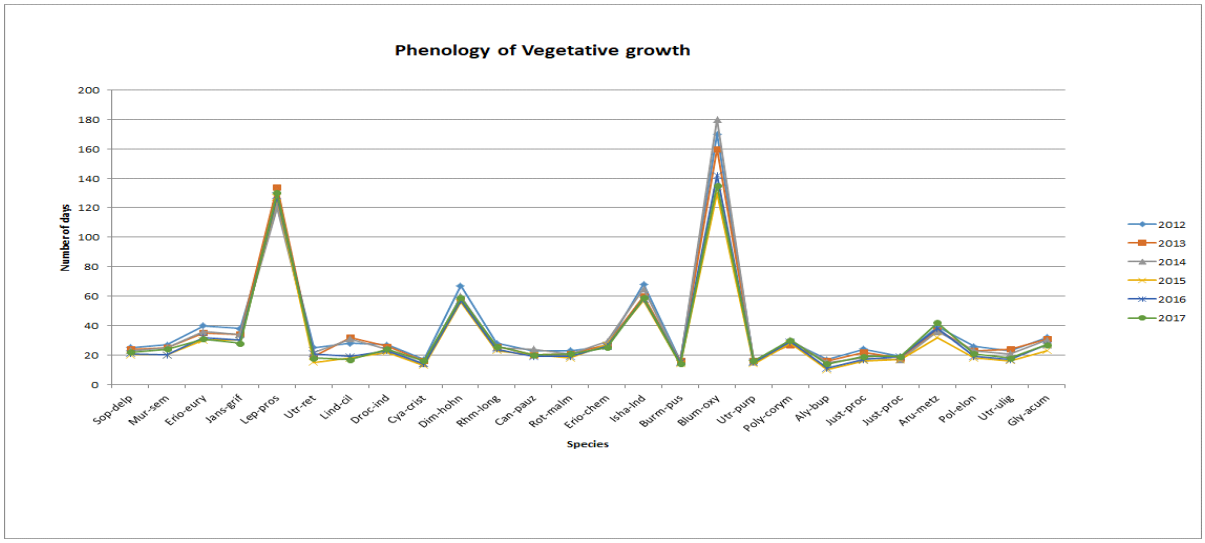


Figure 4.3 Vegetative phenological pattern of herbaceous plants depicted in a line graph.

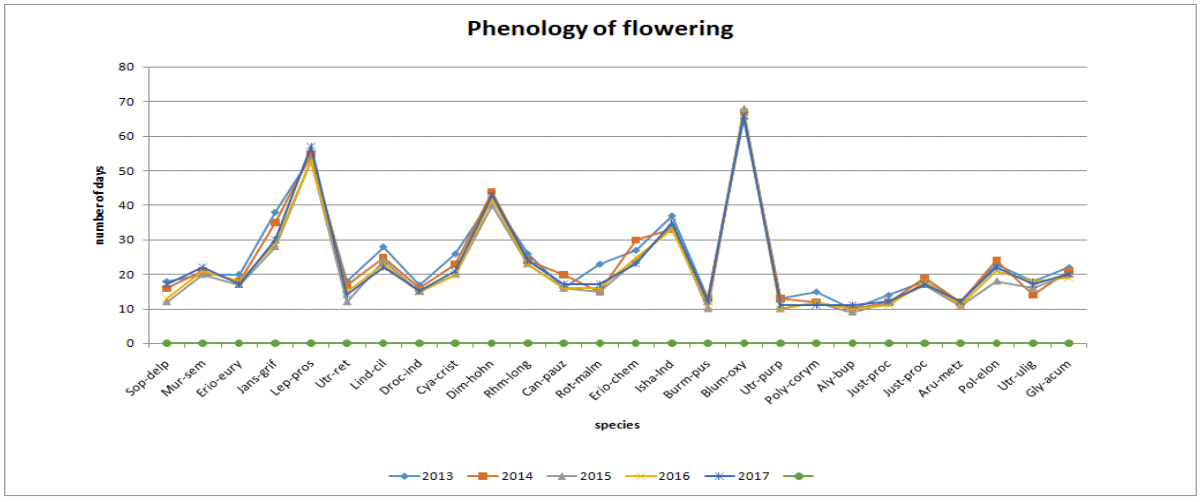


Figure 4.4 Flowering phenological pattern of herbaceous plants depicted in a line graph.

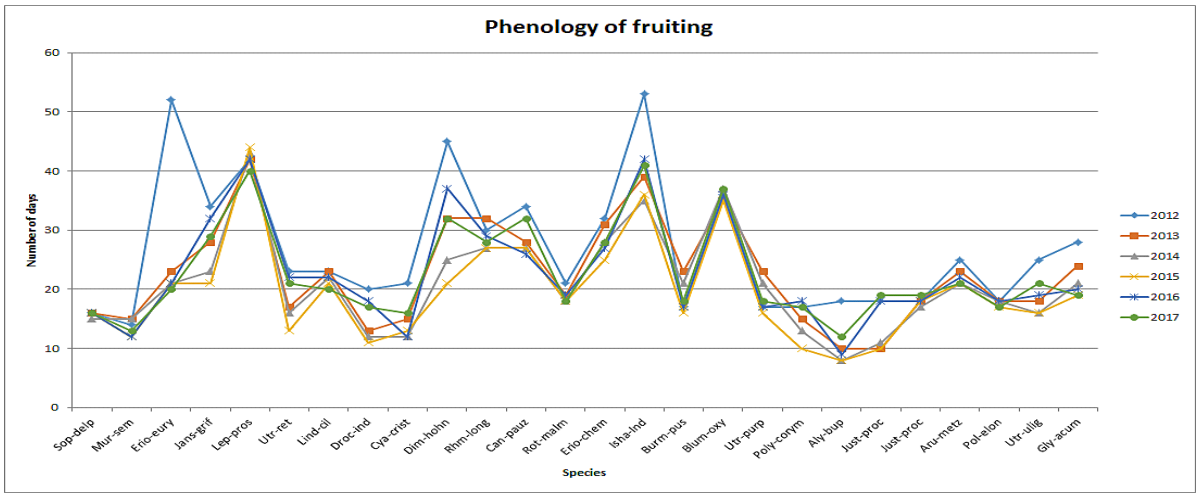


Figure 4.5 Fruiting phenological pattern of herbaceous plants depicted in a line graph.

But there was a drastic decrease in flowering during 2014-2016. During the five study years 2011–12 and 2012–13,2013-14,2014-15,2015-16 the percentage of species in fruiting was 76.9, 88.5 and 84.6,80.2,72.9 respectively. During December-January only 0.76% herbaceous species showed reproductive phenology. Pooled analysis of the data exhibited the highest average flowering (76.9%) in September on 2012; however, average highest fruiting (83.3%) was recorded in October 2013.

On the basis of flowering, 2 species were identified with long flowering duration whereas 21 species were identified with short flowering duration. In the case of fruiting, 3 species showed long fruiting duration and 14 species comes under short fruiting duration (Table 4.2).

Type	Approximate no. of days	No of species
Species with long vegetative duration	120-180	2
Species with medium vegetative duration	35-65	4
Species with short vegetative duration	Less than 30 days	20
Species with long flowering duration	53-69	2
Species with medium flowering duration	43-50	3
Species with short flowering duration	9-30	21
Species with long fruiting duration	35-53	3
Species with medium fruiting duration	16-34	9
Species with short fruiting duration	10-31	14

Table 4.2: Categorization plants based on number of days for phenological events.

Linear correlation between temperature and percentage of species for the number of days for vegetative, flowering as well as fruiting was non-significant; however, average values (taking mean values of all 5 years) had significant association with environmental fluctuations.

Flowering and fruiting phenology varied significantly (P < 0.01) for more than 8 species. Mean values of percentage of species in flowering event indicated highest peak in August followed by September; the highest peak for fruiting (83.3%) was observed in October followed by November (57.7%). *Eriocaulon eurypeplon*, *Sopubia delpinifolia*, *Drosera indica*, *Lindernia ciliata*, *Utricularia malabarica*, *Cyanotis cristata*, *Ramphicarpa longifolia*, *Canscora pauciflora* germinates soon after the onset of monsoon season and completes their life cycle with in a very short period of time. *Lepidagathis prostrata*, *Ischemum indicum*, *Arundinella metzii*, *Blumea oxydonta* were exhibited prolonged duration of vegetative phenology depending on the climatic factors.

Dimeria hohenackeri showed highest pooled average of 79 and 189 days for flowering respectively. However, *Neanotis foetida* pooled the lowest average of 16 flowering days. Highest and lowest pooled average number of fruiting days were recorded for *Crotalaria quinquifolia* and *Utricularia reticulata* with 56 and 15 days/year respectively. Average deviation in flowering among all species was 15.5 days from the first to second year of study; however, this was 15.4 days for the second to third year, resulting in overall 16.4 days of deviation for the entire study period. In the case of fruiting, the deviation was 20.7 and 17.3 days, from the first to second year and second to third year, whereas the pooled deviation was 19 days in fruiting.

The results given in Table 4.3 reveal that there is a significant difference in the different phases of the phenology for species Sop-delp, Murd-sem, Erio-eury, Lep-pros, Dros-ind, Cya-crist, Gly-acum, Pol-elong, Aly-bup, Dim-hohn, Arun-metz, Burm-pus, Just-proc, (P=.001). However, with respect to Jans-grif (P=0.11), Utr-ulig (.374), Aly-bup, Neo-foet (.147), Rot-mal (.568), Lind-cil, Just-proc (0.907), Utr-ret (0.049) no difference in between the phases of phenology was observed.

Species	Monsoon phase	Mean	Std. Deviation	95% Confidence Interval for Mean		ANOVA F value	P value
				Lower Bound	Upper Bound		
Sop-delp	Veg. phase	23.00	1.936	21.51	24.49	10.856	<.001
	Fl. Phase	18.78	4.919	15.00	22.56		
	Frt. Phase	16.22	1.093	15.38	17.06		
Murd-sem	Veg. phase	24.11	2.667	22.06	26.16	41.828	<.001
	Fl. Phase	22.00	1.936	20.51	23.49		
	Frt. Phase	14.67	2.236	12.95	16.39		
Erio-eury	Veg. phase	34.89	3.855	31.93	37.85	12.085	<.001
	Fl. Phase	19.89	2.977	17.60	22.18		
	Frt. Phase	25.22	10.269	17.33	33.12		
Jans-grif	Veg. phase	34.00	5.895	29.47	38.53	2.411	.111
	Fl. Phase	32.56	3.712	29.70	35.41		
	Frt phase	29.11	4.702	25.50	32.73		

Lep. -pros	Veg. phase	130.56	6.747	125.37	135.74	1220.926	<.001
	Fl. Phase	54.67	1.936	53.18	56.16		
	Frt phase	42.11	1.167	41.21	43.01		
Utr-ret	Veg. phase	21.00	3.391	18.39	23.61	3.441	.049
	F phase	17.00	2.915	14.76	19.24		
	Frt phase	20.11	3.822	17.17	23.05		
	Total	19.37	3.702	17.91	20.83		
Lind-cil	Veg. phase	25.22	5.995	20.61	29.83	2.734	.085
	Fl. phase	26.78	4.024	23.68	29.87		
	Frt. phase	22.11	1.900	20.65	23.57		
Droc-ind	Veg. phase	24.89	1.764	23.53	26.24	38.267	<.001
	Fl. phase	16.56	1.424	15.46	17.65		
	Frt phase	16.11	3.480	13.44	18.79		
Cya-crist	Veg. phase	16.33	2.345	14.53	18.14	16.879	<.001
	Fl. phase	24.22	3.667	21.40	27.04		
	Frt. phase	16.44	3.712	13.59	19.30		
Dim-hohn	Veg. phase	63.89	8.313	57.50	70.28	30.975	<.001
	Fl. phase	43.22	3.598	40.46	45.99		
	Frt. phase	35.33	10.368	27.36	43.30		
Ramp-long	Veg. phase	25.78	1.563	24.58	26.98	8.670	.001
	Fl. phase	25.44	2.186	23.76	27.12		
	Frt. phase	29.89	3.444	27.24	32.54		
Can-pauz	Veg. phase	21.67	1.936	20.18	23.16	50.699	<.001
	Fl. phase	18.00	2.398	16.16	19.84		
	Frt phase	30.44	3.504	27.75	33.14		
Rot-mal	Veg. phase	20.33	3.742	17.46	23.21	.579	.568
	F phase	20.67	5.074	16.77	24.57		
	Frt. phase	18.89	1.364	17.84	19.94		
Erio-chem	Veg. phase	26.44	1.130	25.58	27.31	8.107	.002
	F phase	25.89	2.028	24.33	27.45		
	Frt phase	29.33	2.449	27.45	31.22		
Ish-ind	Veg. phase	62.33	4.062	59.21	65.46	76.279	<.001
	F phase	36.00	2.872	33.79	38.21		
	Frt phase	41.67	6.576	36.61	46.72		
Burm-pus	Veg. phase	15.22	1.093	14.38	16.06	23.551	<.001
	Fl. phase	12.56	1.740	11.22	13.89		
	Frt. phase	20.11	3.551	17.38	22.84		
Blum-ox	Veg. phase	149.22	20.431	133.52	164.93	164.821	<.001
	Fl. phase	66.89	1.364	65.84	67.94		
	Frt. phase	39.56	10.702	31.33	47.78		
Utr-purp	Veg. phase	15.67	1.000	14.90	16.44	24.406	<.001
	Fl. phase	12.33	1.936	10.84	13.82		
	Frt. phase	19.89	3.333	17.33	22.45		
Poly-corym	Veg. phase	30.11	2.205	28.42	31.81	101.432	<.001
	Fl. phase	13.11	1.764	11.76	14.47		
	Frt. phase	16.56	3.678	13.73	19.38		
Neo-foet	Veg. phase	14.56	2.506	12.63	16.48	2.076	.147
	Fl. phase	12.11	2.892	9.89	14.33		
	Frt. phase	12.00	3.536	9.28	14.72		
Aly-bup	Veg. phase	20.89	3.480	18.21	23.56	10.599	.001
	Fl. phase	12.56	1.424	11.46	13.65		
	Frt. phase	16.89	5.487	12.67	21.11		
Just-proc	Veg. phase	18.78	1.481	17.64	19.92	.098	.907
	Fl. phase	19.11	1.833	17.70	20.52		
	Frt phase	19.11	2.147	17.46	20.76		
Arun-metz	Veg. phase	40.33	5.431	36.16	44.51	146.089	<.001
	F phase	12.89	1.965	11.38	14.40		
	Frt. phase	22.00	1.658	20.73	23.27		
	Total	25.07	12.099	20.29	29.86		
Pol-elong	Veg. phase	22.33	2.646	20.30	24.37	13.767	<.001
	Fl. phase	22.89	3.257	20.38	25.39		
	Frt. phase	17.33	.866	16.67	18.00		
Utr-ulig	Veg. phase	20.33	2.915	18.09	22.57	1.025	.374
	Fl. phase	18.33	3.500	15.64	21.02		
	Frt. phase	20.00	3.082	17.63	22.37		
Gly-acum	Veg. phase	29.56	3.644	26.75	32.36	14.797	<.001
	Fl. phase	22.33	2.915	20.09	24.57		
	Frt phase	22.22	3.232	19.74	24.71		

P* <0.05 IS Significant, P*<.01 Highly significant

Table 4.3: Mean, standard deviation and 95% confidence interval for life span of different species along the different monsoon phases and their comparison.

Year wise, there was not any significant differences in the mean life of *Lepidagathis prostrata*. It might be due to the drought enduring capacity of the species (Table 4.4). But certain species showed significant results, *Utricularia reticulata* (0.008), *Lindernia ciliata* (0.028), *Neanotis foetida* (0.002), *Utricularia uliginosa* (0.012) it might be due to the fluctuation in environmental factors like rainfall, humidity and Temperature.

Species	Model	R	R Square	Adjusted R Square	ANOVA p value	Prediction: Dependent/Independent on phases
Sop-delp	1	.689(a)	.475	.431	.000	Dependent
Murd-sem	1	.882(a)	.777	.758	.000	Dependent
Erio-eury	1	.708(a)	.502	.460	.000	Dependent
Jans-grif	1	.409(a)	.167	.098	.111	Dependent
Lep-prost	1	.995(a)	.990	.989	.000	Dependent
Utr-ret	1	.472(a)	.223	.158	.049	Dependent
Lind-cil	1	.431(a)	.186	.118	.085	Not dependent
Droc-ind	1	.873(a)	.761	.741	.000	Dependent
Cya-crist	1	.765(a)	.584	.550	.000	Dependent
Dim-hohn	1	.849(a)	.721	.697	.000	Dependent
Ramp-long	1	.648(a)	.419	.371	.001	Dependent
Can-pauz	1	.899(a)	.809	.793	.000	Dependent
Rot-mal	1	.215(a)	.046	-.033	.568	Not dependent
Erio-chem	1	.635(a)	.403	.353	.002	Dependent
Ish-ind	1	.930(a)	.864	.853	.000	Dependent
Burm-pus	1	.814(a)	.662	.634	.000	Dependent
Blum-oxt	1	.965(a)	.932	.926	.000	Dependent
Utr-purp	1	.819(a)	.670	.643	.000	Dependent
Poly-corym	1	.946(a)	.894	.885	.000	Dependent
Neo-foet	1	.384(a)	.147	.076	.147	Not dependent
Aly-bup	1	.685(a)	.469	.425	.001	Dependent
Just-proc	1	.090(a)	.008	-.075	.907	Not dependent
Arun-metzi	1	.961(a)	.924	.918	.000	Dependent
Pol-elong	1	.731(a)	.534	.495	.000	Dependent
Utr_ulig	1	.280(a)	.079	.002	.374	Not dependent
Gly-acum	1	.743(a)	.552	.515	.000	Dependent

a Predictors: (Constant), Veg. phase, Frt. phase, Fl. Phase.

Regression analysis: Prediction of individual species dependency over climatic fluctuations (Model summery).

Table .4. 4: Mean and deviation in reproductive phenology of monsoon flora of grassland.

5.Seasonal succession

5.1.1: Study area

Detailed information about study area and climatic conditions and sampling plot designs are given in Chapter 3. Sampling plots were located on a plain grassland plateau representing different types of microhabitats. Six sampling sites were selected, comprising of Site 1-Ephemeral flush vegetation (EFV), Site II- Temporary water pool (TMP)Site III- Soil filled areas (SFA), Site IV- Rock surface crevices. Site V-Disturbed areas (DA) and Site VI- Site III-Grassy slopes.

5.2.2: Successional trends

Plant communities in the study region were continuously changing with respect to change in rainy season and other environmental factors. Each species found in successive stages were adapted to specific climatic conditions. Early phase of monsoon (June-July) was period of vegetative growth and germination of perennating tubers and early ephemerals. Mass flowering patterns and relative cover of early and late annuals in each stage indicate a trend toward increasing dominance by grasses. Few Acanthaceae perennials were seen in the winter and summer period with unique habitat specific adaptations. During seasonal succession, different plants species occurred in varying abundances that reveal fluxes in their pattern of establishment in different years. Diagrammatic representation of overall succession pattern is given in Figure 5.1. Richness of families in herbaceous species during successive phases is (families with 4 or more taxa shown) represented in Figure 5.2. Comparison of conditions of plateau ground is given in Table 5.1.

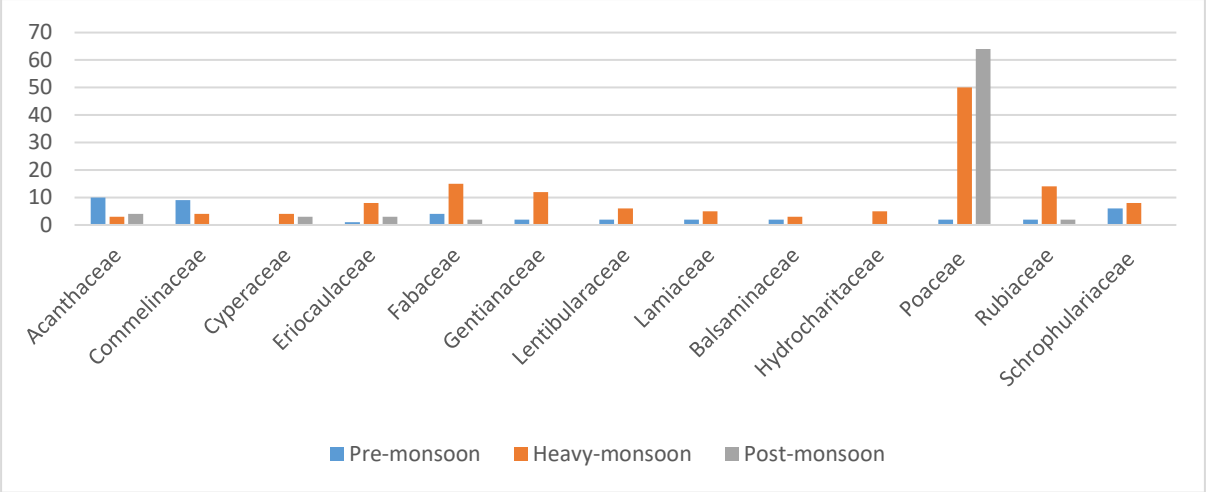


Figure 5.1: Richness of families in herbaceous species during successive phases (families with 4 or more taxa shown).

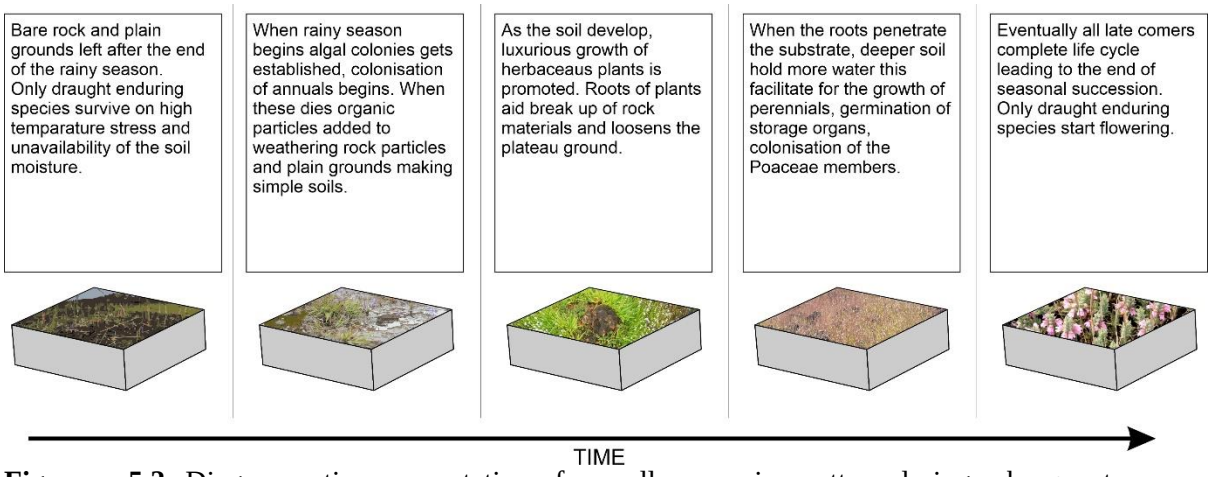

Bare rock and plain grounds left after the end of the rainy season. Only draught enduring species survive on high temparature stress and unavailability of the soil moisture.
When rainy season begins algal colonies gets established, colonisation of annuals begins. When these dies organic particles added to weathering rock particles and plain grounds making simple soils.
As the soil develop, luxurious growth of herbaceaus plants is promoted. Roots of plants aid break up of rock materials and loosens the plateau ground.
When the roots penetrate the substrate, deeper soil hold more water this facilitate for the growth of perennials, germination of storage organs, colonisation of the Poaceae members.
Eventually all late comers complete life cycle leading to the end of seasonal succession. Only draught enduring species start flowering.
TIME

Figure 5.2: Diagrammatic representation of overall succession pattern during subsequent stages.

Bare ground in Summer	**Plant rich ground in Monsoon phase**
No plant competition for light, space, nutrients or water. Soil is mobile and liable to erosion and loss.	Formation of microhabitats, increased plant-pollinator interaction, intense plant competition for space and other resources, soil bound by roots and plant cover.
A more extreme surface microclimate because the bare laterite rocky surfaces and soils both absorbs and reflects heat more than soil covered in vegetation.	Cool monsoon weather provides ambient time for luxurious growth of the vegetation and the plant cover provides a certain amount of ground insulation from extremes climatic variations. Variety of microclimates within the vegetation is very specific in ecological adaptations and interactions.
A drier environment because there is no plant cover to hold moisture above ground and no humus and grass root network to hold it in the soil.	Alternating plant covers because of seasonal succession and increasing humus levels help to retain water.
Overall hardness of soil prevents mobilization of nutrients to the plants.	Abundant water and nutrients are available to the plants due to soft soil texture.

Table 5.1: Comparison of atmospheric conditions of plateau ground.

5.2.3: Seasonal turnover of herbaceous plant communities

Population dynamics in Konaje permanent plot during successive stages:

Stage I: (End of May)

Habitat/Soil response: When it rains, water that falls to the soil's surface will either infiltrate or run off along the surface. The surface soil layers will absorb some of the water that infiltrates the soil, while the deeper soil layers will absorb the rest.

Plant community response: *Impatiens minor*, *Neanotis foetida* (Completes their life cycle with in very short period of time).

The beginning of wet phase during late May or early June stimulates the germination of seeds and the growth of specific habitat preferring annual plants. The early germinating plants are mainly ephemerals and r-strategists, which partially complete their life cycles in two weeks.

Associated responses: Tuberous and bulbous plants such as *Curculigo orchioides* and ground Orchids are also seen associated with early comers. These can thrive under warm and less rainy days. Perennial grasses belonging to *Aristida*, *Arthraxon*, *Brachiaria* starts sprouting in the adjacent areas of the plot.

Stage II: (June-July)

Habitat/Soil response: Plateau region starts getting sufficient rain water, so that humus can be produced naturally. The leaf litter will degrade over time and create nutrient-dense humus. In the entire plateau region, there will be a large quantity of moisture content and atmospheric humidity. The habitat becomes lush and verdant, with newly emerging annuals covering the entire region.

Plant community response: *Heliotropium marsupium*, *Murdannia semepteres*, *Zornia gibbosa* starts flowering.

As vegetative phase of late perennials shows luxurious vegetative growth, early annuals flower in this time. Later they are replaced by heavy monsoon requiring plant species. There is an exponential rise in the second weeks of the growing season and a peak attained after two weeks.

Associated responses: When the early germinated ephemerals end their life cycle, a set of another group of individuals like *Utricularia'*s, *Hebeneria'*s, *Eriocaulon'*s dominate the area.

Stage III: (Heavy monsoon phase)

Habitat/Soil response: Following the heavy rainfall, preferential water flow initially occurred through macropores, decayed plant roots, and rocks at different depths of the soil. With the continued rain, the litter and surface soil became substantially or completely wet, and infiltration became homogeneous.

Plant community response: This is the time for mass blooming in different set of plant groups. For example (*Eriocaulon cheemenianum, Utricularia lazulina, Canscora diffusa, Eriocaulon eurypeplon, Utricularia purpurea, Microchloa indica*), (*Canscorinella bhatiana, Canscora pauciflora, Justicia procumbens*), (*Polygala elongata,Utricularia malabarica, Cyanotis cristata, Drosera indica, Alysicarpus vaginalis, Hedyotis cyanantha, Lindernea crustacea, Fimbristylis tetragon, Oryza rufipogan, Wiesneria triandra, Rotala rotundifolia, Nymphoides parviflora*) and (*Crotalaria quinquifolia, Blyxa mangalensis, Eriocaulon richardianum, Eriocaulon cuspidatum*) were recorded in this period.

Associated responses: The peak of species number and species diversity index occurs. Another set of ephemerals germinates in this period also**.** At the same time these ephemerals are joined by luxurious vegetative growth of late flowering perennials and K-strategists.

Stage IV:

Habitat/Soil response: The heavy monsoon season ends in October, and warm, sunny days return. Which results in slow drying up of habitats. Large water pools will retain water for another two months supporting great number of diversities.

Plant community response: Late comers start flowering and there will be a clear transition phase observed when stage III plants decline in flower and Stage IV plants (*Arundinella metzii, Jansenella griffithiana, Pasapalum conjugatum, Dimeria hohenackeri, Polycarpea corymbosa, Exacum sessile, Eragrostis indica*) starts flowering.

Associated responses: Different species belonging to *Eragrostis*, *Glyphochloa*, *Isachne* grow in patches and the green vegetative phase look forward for a period of short monsoon days to complete their life cycle. *Burmannia*, *Spermacoce*, *Sesamum* and grasses such as *Arundinella*, *Dimeria*, *Ischaemum*, *Panicum* dominates the habitats subsequently.

Stage V:

Habitat/Soil response: The Withdrawing or retreating Monsoon begins in Middle October and ends in November. After a small period of dry phase plateaus will experience monsoon days for a week. This will enhance luxurious flowering in grasses.

Plant community response: *Dimeria* spp and *Eragrostis* spp cover 50% in the community. *Polycarpaea corymbosa* can also be seen in flower.

Associated responses: Toward the end of the season 95% of annuals are eliminated and a few perennials assume dominance. This trend is related to the exponential rise in the species diversity index at the early part of the growing season until stage IV, and then a fall occurs as the perennials assume dominance. That means that majority of the species have already completed their life cycles and that the rate at which new individuals are added to the community is drastically declined when compared to the rate at which old ones are dying.

Stage VI: (January – May)

Habitat/Soil response: Due to the high temperature, winter stress, water scarcity, and soil moisture loss, the dry phase with greater winds and direct sunshine accelerates the drying process of the flora. Because the entire plateau dries up and the intensity of sunlight increases during the summer, the entire vegetation mass is eliminated. Dry grasses can indeed quickly catch fire.

Plant community response: *Lepidagathis prostrata* and *Blumea oxydonta* may remain spread all over the rocky regions of the plateau.

Associated responses: Forest covers and shrub patches provide adequate place for shade loving under-herbs. For example, *Pancratium triflorum* and *Liparis rheedii*.

5.2.4: Diversity indices

Temporary water pool (Site II) and Soil filled depressions (site III) region are maximum species rich having Shannon diversity index and Simpson value i.e., D = 0.89 & 0.93 respectively on heavy monsoon phase. In the weed disturbed region, diversity index values are lowered drastically, with Simpson value index from 0.16-0.60 and Shannon diversity index 0.38-0.4. This is due to the dominant ruderal species like *Spigelia anthelmia*, *Cassia tora* etc. Whereas grassy hill slopes are usually dominated by few Poaceae members in the late succession stages with maximum Simpson value index and Shannon diversity index ranging from 0.56 and 0.30 -2.28 respectively (Figure 5.2 & Figure 5.3). However highest Fischer alpha index was shown by Soil filled areas i.e., 11.4 and 10.32 respectively.

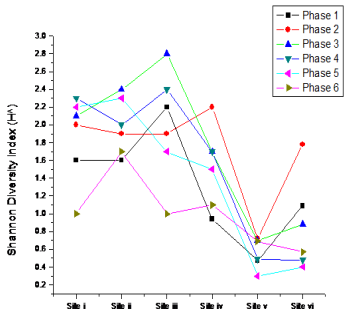


Figure 5.3: Simpson diversity indices during successive stages.

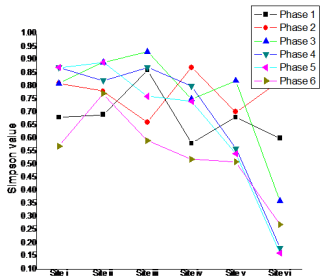


Figure 5.4: Shannon diversity indices during successive stages.

5.2.5: Cluster analysis

Cluster analysis was used to group together stands of similar species composition. These groups were then analyzed to identify successional patterns and relationships among the stands. The dendrogram of grassland plots can be divided into seven major groups (Figure 5.5a). Group 1, containing three representative species like *Impatiens minor*, *Neanotis foetida* and *Senna tora* which germinates easily during the first week of rainy season. The second group contains *Lepidagathis prostrata* and *Blumea oxydonta*. This group stands contain the elements which can withstand the

conditions of post monsoon season. Group 3 consists of *Smithia conferta, Burmannia pusilla*, *Cyperus pangorei*, *Sopubia delphinifolia*. Group 4 is a heterogeneous collection of species ranging from *Leucas linifolia*, *Polygala elongata, Mollugo pentaphylla, Commelina cristata, Eriocaulon cheemenianum, Utricularia malabarica, Canscora bicolor, Rhamphicarpa fistulosa, Canscorinella bhatiana, Canscora paucifolia*, *Hebenaria diphylla*, *Drosera indica*. Group 5 consists of *Heliotropium marifolium, Utricularia purpurascens* and *Murdannia semepteris*, these kind of annuals with very short life span (approximately 30-50 days) can persist the heavy monsoon phase. Group 6 consists of *Spermacoce hispida*, *Eragrostis indica*, *Polycarpea corymbosa* etc. Vegetation at this time is dominated by Poaceae members along with some late germinating ruderals. Group 7 consists of *Eragrostis tenella, Arundinella metzii, Jansenella griffithiana, Dimeria hohenackeri.*

Vegetation dynamics in temporary ponds followed different pattern of vegetation (Figure 5.5b). Group 1 containing three representative species's like *Ischaemum mangaloricum* and *Marsilea minuta* (aquatic fern). The 2 group contains *Nymphoides indica, Rotala malampuzhenis* and *Utricularia reticulata*. Group 3 consists of *Eriocaulon cuspidatum, Crotalaria quinquifolia*. Group 4 consists of *Pycreus macrostachyos*, *Oryza rufipogon*, *Fimbristylis tetragona*, *Geissaspis cristata*, *Utricularia reticulata, Wiesneria triandra, Crotalaria quinquefolia*. Group 5 consists of *Blyxa mangalensis*, *Eriocaulon richardianum.* No distinct species grouping was possible suggesting that successional stages cannot be clearly identified on site by cluster analysis. But the composition of these stands show that successional changes solely depend on monsoon climatic changes. Detailed information about the life stages of representative species in the study area is given in Table 5.2 & 5.3.

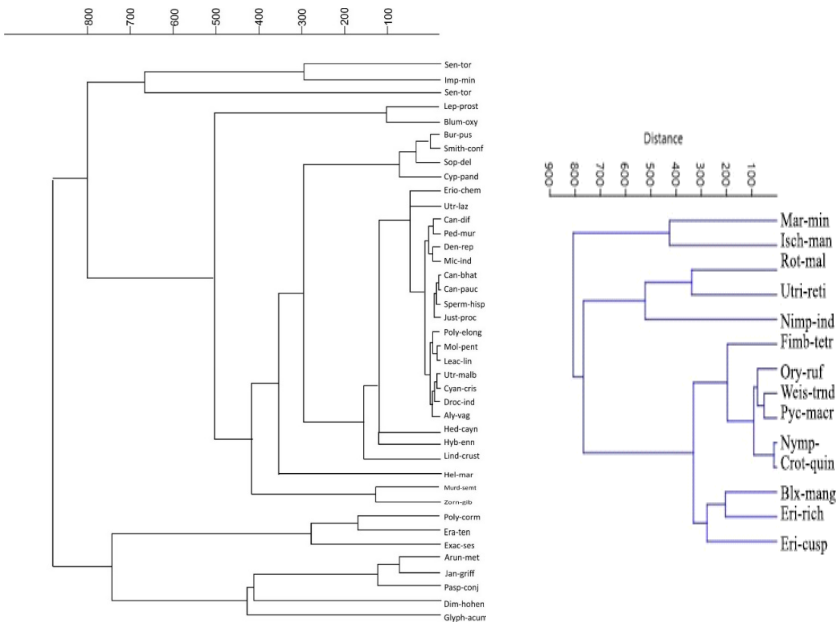


Figure 5.5a & 5.5b: An unweighted pair group cluster analysis of stands study areas.

SL.No	Species	Stage 1	Stage II	Stage III	Stage IV	Stage V	Stage VI
Group 1	*Senna tora, Impatiens minor,Neanotis foetida*	Quick germination of seeds and Vegetative phase	More lateral branches develop	Flowering starts	seed setting phase starts	Completion of lifecycle	-
		For the first period of monsoon (June 1- June 15) *Senna tora, Impatiens minor, Neanotis foetida* were the most widely prevalent species. These three annuals can immediately germinate on second week of June.					
Group 2	*Lepidagathis prostrata, Blumea oxydonta*	-	Root stocks starts growing	Vegetative growth	Vegetative growth	Vegetative growth	Flowering stage begins
		These perennial plants appear to have responded immediately to rainy season, by producing new shoots from the already available rootstock in the soil or by seedling from the surrounding areas.					
Group 3	*Burmannia pusilla, Sopobia delphinifolia, Cyprus pangrai, Smithia conferta*	-	Embryonic leaves germinate	Flowering stage starts	Flowering continues	Seed setting phase starts	Completion of life cycle
		During the course of next few days (June 15-June 30), site conditions improved favorably and allowed the germination of a few annual plants. *Burmannia pusilla, Sopubia delphinifolia* were the most dominant flowering annuals.					
Group 4	*Eriocaulon cheemenianum, Utricularia lazulina, Canscora diffusa, Ramphicarpa fistulosa, Dentella repens, Micrococa indica*	-	Embryonic leaves germinate	Flowering stage starts	Flowering continues	Completion of lifecycle	-
		When the heavy monsoon phase starts *Eriocaulon cheemenianum* and *Utricularia lazulina* were more aggressive at one stage. But later *Canscora diffusa* and *Rhamphicarpa fistulosa* dominates.					
	Canscorinella bhatiana, Canscora paucifloa, Spigelia anthelmia, Justicia procumbens	Increased embryonic leafy stage and fast growth of true leaf development	Increased number of lateral branches	1-2 sets of inflorescences in each branch	Increased number of inflorescences	Fruit setting stage, flowering continues	Old leaves dry up, no flowering, Fruits mature
		Spermacoce hispida became more aggressive and suppressed the growth of other annuals at one stage. But two co-dominant species *Canscorinella bhatiana* and *Canscora pauciflora* co-existed with other less aggressive species like *Drosera indica* and *Burmannia pusilla* (From the beginning of August -Middle of September).					
	Polygala elongata, Mollugo pentaphylla,	Embryonic leaves slowly germinate	Two set of leaves mature	Dominant flowering stage	Fruit setting stage	Completion of lifecycle	-

	Leucas linifolia,Utricularia malabarica,Cyanotis cristata, Drosera indica,Alysicarpus vaginalis, Hedyotis cyanantha,Hybanthus enneaspermus,Lindernia crustacea	During heavy monsoon phase *Polygala elongata*, *Utricularia malabarica* and *Drosera indica* continued to have a steady existence in the area (25-35 days).					
Group 5	*Heliotropium marifolium, Murdannia semepteris, Zornia gibbosa*	Embryonic leaves germinate, fast vegetative growth	Dominant flowering stage	Fruit setting stage	Completion of lifecycle	-	-
		When *Drosera, Neanotis* and *Utricularia* subsequently declined flowering, *Murdannia* and *Heliotropium* becomes widely occurring plant species.					
Group 6	*Polycarpea corymbosa, Exacum sessile, Eragrostis tenuiflora*	-	-	Embryonic leaves germinate	Vegetative phase begins	Prolonged flowering stage	Fruit maturation stage and completion of life cycle
		Eragrostis was observed to have a high density (vegetative stage) during middle September when compared to other plants. *Polycarpea corymbosa* began to appear along with *Eragrostis* and continues to flower till the end of November.					
Group 7	*Arundinella metzii, Jansenella griffithiana, Paspalaum conjugatum, Dimeria hohenackeri, Glycophloa acuminata*	-	Embryonic leaves germinate	Fast vegetative growth	Flowering starts	Dominant flowering stage	Fruit setting Stage and completion of life cycle
		Glyphochloa has high density in the beginning, but once monsoon declines *Eragrostis*, *Arundinella*, *Paspalum*, *Dimeria* etc., emerged as dominant species till the end of November.					

Table 5.2. Detailed information about life stages of representative species in the study region (Site: I, III, IV, V)

SL.No	Species	**Stage 1**	**Stage II**	**Stage III**	**Stage IV**	**Stage V**	**Stage VI**
Group 1	*Ischaemum mangaloricum, Marsilea minuta*	Seasonal ponds provide conducive environment for the early establishment and growth of habitat specific Poaceae member *Ischaemum mangaloricum* and an aquatic fern *Marsilea minuta*. These early niche occupiers germinate during first week of June and dominance increases till September end.					
Group 2	*Rotala malmpuzhensis*, *Utricularia retriculata, Nymphoides indica*	Leaves germinate	Vegetative stage	Flowering stage	Fruit setting Stage	Completion of life cycle	-
		Over the period of continuous two weeks rainy season *Rotala*'s and *Utricularia*'s germinates in the peripheral edges of ponds, where sufficient soil moisture and water depth is available. Whereas higher densities and abundance of *Nymphoides indica* is seen in the middle of pond with high water depth during the middle of September.					
Group 3	*Fimbristylis tetragona, Pycreus macrostachys, Oryza rufipogan, Wiesneria triandra, Rotala rotundifolia, Nymphoides parviflra, Crotalaria quinquifolia*	-	Fast vegetative growth	Flowering begins	Dominant flowering stage	Fruit setting Stage	Completion of life cycle
		Immediately after 25 days of continuous rainy season *Fimbrytylis tetragona* and *Oryza rufipogon* emerges in the shallow depth region of the pond. It is noticed that in the peripheral regions of the pond early germinators decline soon at the end of September and late germinators emerged as dominant species. When Group 2 members starts early flowering stage, members of group 3 observed to have a high density with vegetative growth stage during July end. *Crotalaria quinquifolia* takes approximately 35-45 days to reach flowering stage. *Eriocaulon cuspidatum* continued to exist over post monsoon phase until the soil moisture content is retained.					
Group 4	*Blyxa mangalensis, Eriocaulon richardianum,Eriocaulon cuspidatum*	-	Fast vegetative growth	Dominant flowering stage	Fruit setting Stage	Fruit setting Stage declines	Completion of life cycle
		Annuals with short life span (Approximately 50-70 days) comes under group 5. During the beginning of July to late September *Blyxa mangalensis* and *Eriocaulon'*s co-existed with less aggressive species like *Crotalaria quinquefolia.*					

Table 5.3: Detailed information about the life stages of representative species in the temporary pond (Site II).

6. Other uses/Ecosystem services of plateaus

6.1.1: Pollination services

Pollination services are known to provide substantial benefits to all flowering plants. Different types of pollination mechanism were observed in the grassland plateau. Anaemophily is the characteristic feature of Poaceae members which cover 70 % of the grassland flora followed by (29.2%) entomophily. Various species exhibited adaptations for pollination mechanism. For example, flower colour changes in *Neanotis foetida* and *Utricularia'*s to attract honeybees. *Crotalaria'*s and *Sesamum radiatum* exhibit dark coloured flowers to attract Carpenter bees. During hot summer days *Lepidagathis* spp starts flowering and these flowers are easily accessible by ants and other pollinating insects.

Among hydrophytes there are rooted emerging plants which are adapted for entomophily or anaemophily. But submerged hydrophytes are characteristically known for hydrophily. During the course of study, we could report an interesting pollination mechanism in newly reported dioecious species *Blyxa managalensis* which shows hydrophily. The male and female plants are seen in the same ratio. The plants appear in the beginning of July and remain until the middle of October. Flowering starts in August. Male plants flower earlier than female plants. A male plant produces 10 − 14 spathes and a female plant produces 8−10 spathes, one after the other.

The pollen mass released from male flower can be seen moving randomly on the water surface in the early morning on bright sunny days. 8-10 pollen masses will be seen deposited on the stigma. The papillate stigma folds over and entraps the pollen masses. After about 30 hours of pollen deposition, stigma disintegrates. Pollination appears to be very efficient and capsules are usually full of viable seeds.

6.1.2: Ethnobotanical significances

One of the major importance of grassland plateau is availability of medicinal plants. The majority of the medicinal plants recorded are herbs (24 species), followed by shrubs (19 species), trees (19 species), and climbers (16 species) (Annexure IV). Month wise contribution of ethno botanically significant plants in the study region is represented in (Figure.6.1).

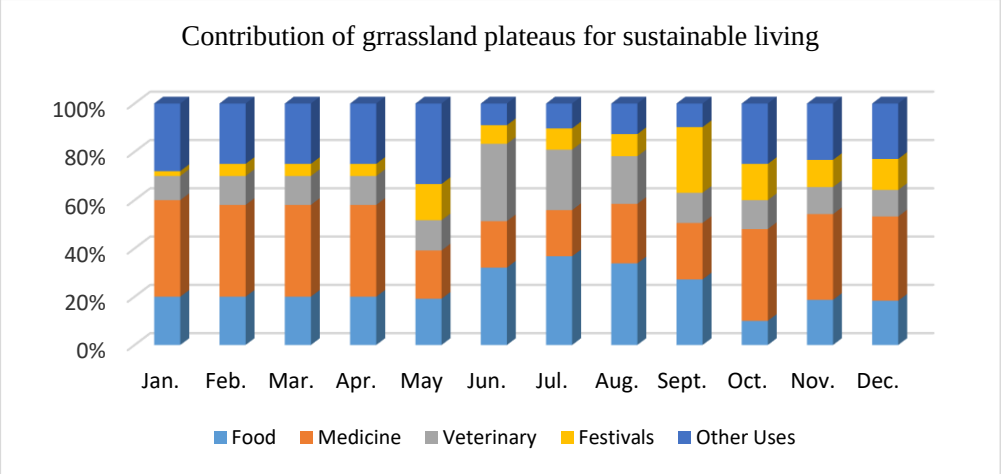


Figure 6.1: Month wise contribution of ethno botanically significant plants in the study region.

Medicinal Uses: Interesting medicinal plants species have been documented. Especially documentation of plants like *Lepidagathis prostrata* used as medicated rice, *Hybanthus ennyaspermus* used as coolent, *Xyris indica* used to treat Skin allergy. Roots of *Ventilago madaraspatana*, which is the main ingredient in making massage oils for new born, is found in the study area. All these shows the plateau as an important source of medicinal plants.

Edible Uses: Tender leaves of *Careya arborea*, *Syzigium caryophyllatum*, *Caesalpinea mimusoides*, *Ixora brachiata* are commonly used by many communities to make delicacies.

Garcinia indica, a wild crop is now widely cultivated by many farmers. Flowers of *Hollarhena antidysentarica*, *Carrissa conjesta*, *Asystasia gangetica* stem, *Hibiscus surattensis* are some of the other prominent plants, parts of which are edible.

Collection of Honey: People rear honeybees during the flowering season of *Strychnos nux-vomica* and *Syzigium caryophyllatum* to collect the nectar from the flowers.

Ethnoveterinary plants: *Allophyllus cobbe* commonly seen in the study area is widely used to cure Uddermastitis. *Pogostemon quadrifolius*, which bears a strong aromatic smell, is very common in laterite plateaus. The leaves of this plant rubbed gently on the body of the cattle keep parasites away.

Cultural significance: Grassland plateaus are an integral part of the cultural lives of the people living in the study area. Aati Kalenja is an ancient traditional folk-art form practiced by Tulu people from the region of Tulu Nadu, Dakshina Kannada, Karnataka State, India, which is believed to bring prosperity during Aati, which is one of the months in Tulu calendar. It normally comes in the month of July and August. The person who masquerades as Kalenja makes the headgear using stems of *Ixora coccinea* (Kepula in Tulu language).

The fourth month of the Hindu year is called 'Sone thingalu' or 'Shravana'. It begins on the first day of the full moon in late July and ends on the first day of the next full moon in the third week of August. During this time *Impatiens minor*, *Utriculaia*'s, *Eriocaulon'*s and many other herbaceous flowering plants are used to prepare 'soodi' (small flower bouquets) and used to decorate thresholds to welcome lord Lakshmi.

Kaaka poovu (*Utricularia*), found in the study area is a flower used extensively during the Onam celebration in Kerala. In fact, in the olden days flowering of *Utricularia*, signaled the arrival of festive season. The small white flowers of *Leucas linifolia* is the very essential of the Onam festivities. On the day of Atham, the pookalam consists of only these flowers.

Paade Poo (*Polycarpea corymbosa*), another flowering plant found in rock crevices during post monsoon phase is used for major rituals during the 'Balindra Pooja' performed during the Diwali festival.

6.1.3: Temporary pools as water reservoirs

Pallam is a natural water pool that can be found in rocky plateaus. It's known as a pallam or Palla in Kasaragod. Parakulams, or rock ponds, are the name given to them in Kannur.

For eight months of the year, these natural reservoirs store rainfall. The pallam are crucial for the ecosystem and helps recharge the ground water table. A mid-sized pallam can stretch up to an acre in size. Laterite pores are loaded with bauxite clay, which slows down rainwater seepage.

Bedrampalla in Maniyampara, Katukukke palla near Perla, Anadipalla near Puttige in Kasaragod district and Madayipara rock ponds are few notable water reservoirs observed in the study region. The temple ponds of Mujungavu and Ananthapuram

in Kasaragod district are also home to hundreds of birds and turtles. Both are perennial ponds.

6.1.4: Suranga or Thurangam

Surangas are similar to a horizontal hole or cave carved in hard laterite soil formations from which water seeps out and runs into open ponds. A typical suranga can run from anywhere between 50 metres to 500 metres through a hill. This is a conventional water management technique that ensures a consistent supply of water to human settlements. This traditional irrigation system can be seen in Kasaragod district of Kerala and Dakshina Kannada district of Karnataka, India.

DISCUSSION

Species composition: Of the flora documented, 393 herbaceous species were belonging to four major clades and 25 orders. Asterids represented 71 genera followed by monocots (66) and rosids (37). Monocot (172) was the most speciose clade followed by asterids (125) and rosids. This observation can be related to the earlier researches about species composition of grassland plateaus made by Lekhak &Yadav (2012), Rahangdale & Rahangdale (2014), Pramod & Pradeep (2021).

The extreme variation in species richness among the families of Poales might be due to ability of grasses to inhabit open and dry environment. Poales are well adapted for C_4 and CAM (Crassulacean acid metabolism) photosynthesis in varied atmospheric CO_2 concentrations. Variations in species richness could also be attributable to a variety of external and intrinsic variables. (Yanis Bouchenak-Khelladi, 2014). Species rich families like Poaceae and Cyperaceae are important on inselbergs or throughout temperate and tropical regions (Magallon & Castillo,2009; Karthikeyan,2009; Yadav & Sardesai, 2002; Bathlott & Porembski, 2000).

In different research locations, there was significant variance in species composition, density, and diversity. For instance, no common species was found in all quadrats. *Rotala malampuzhensis* and *Eriocaulon eurypeplon* were frequent with a frequency of 0.05. *Leucas linifolia*, *Polygala elongata*, *Rungia pectinata*, *Impatiens minor* showed rapid increase in species density values during early stages of succession (Fig. 6.2). Overall succession pattern indicate that there are two distinct clusters with high species density and 3-4 associated clusters with low density values. At the end of succession annual grasses like *Eragrostis*, *Paspalum* and *Dimeria* were most abundant species. *Lepidagathis prostrata* was frequent (11.86) during dry phase. In contrast, diversity and evenness increases with time in a study by Kaputska & Moleski (1976).

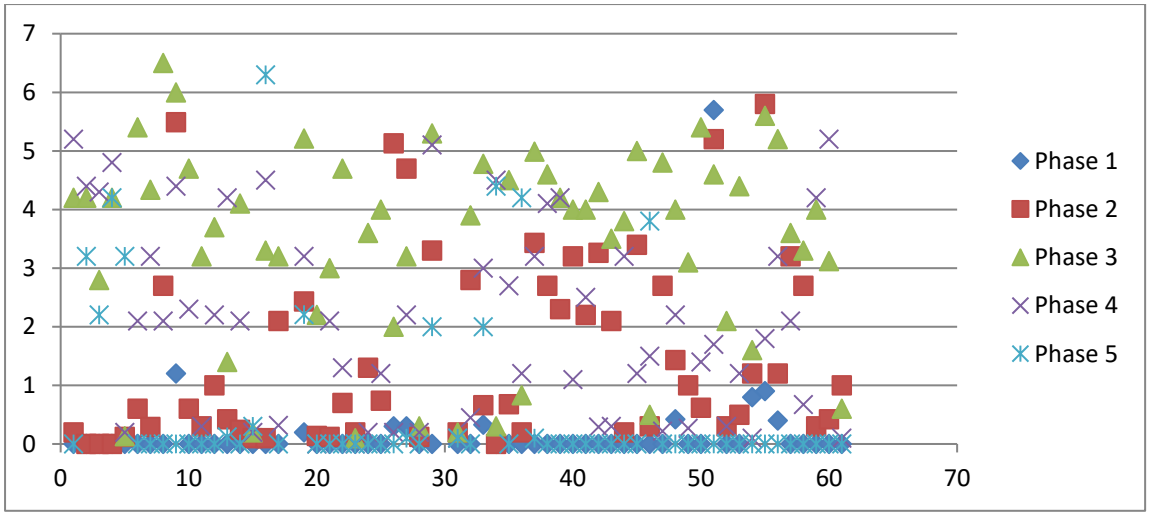


Figure 7.1: Plant density changes during the succession stages.

Rahangdale & Rahangdale (2014) observed, rock outcrops which are under similar geographical conditions and are separated by less distance are diverse from each other, indicating high level of beta diversity for plant communities. Harrison et al., (2006), Brown (1984), Gaston et al., (2000), He & Condit (2013), Rindorf & Lewy (2012) stated that, species richness on rocky plateaus are influenced by historical, environmental and several other important factors.

Endemism: This study resulted in recording 96 herbaceous endemics from LROs of study region. The studies made by Dhatchanamoorthy & Balachandran (2021), Irwin & Narasimhan (2011) also highlights the occurrence of greater number of endemic species and genera in Southern part of India.

Altitude specificity: When low altitude herbaceous plants distribution is compared along with high altitude plateaus, by our observation and references (Lekhak & Yadav,2012; watve, 2013), significant plant distribution pattern is observed (Table 7.1). Order Poales ranks first at ranks of genera, total taxa and endemic taxa in both altitudes. Order Asparagales have a greater number of taxa in higher altitude and order Lamiales and Gentianales at low altitude. Genera like *Utricularia*, *Eriocaulon*, *Dimeria*, *Eragrostis* have a greater number of taxa in both the altitudes (Lekhak and Yadav,2012; Rao et al.,2012). We have tried to compare altitude wise distribution of endemic taxa based on few important references. According to Ganesh et al., (1996) SWG is more diverse in endemic tree species and Northern Eastern Ghats is very significant for endemic herbaceous flora. Joshi and Janarthanam (2004) also documented maximum herbaceous endemics from NWG of Goa. In the present study

Ischaemum yadavii, *Lepidagathis keralensis*, *Lepidagathis clavata*, *Spermacoce malabarica*, *Rotala malabarica*, *Rotala tulunadensis*, *Rotala kasaragodensis* are recorded which were otherwise known only from their type locality.

Study region	**Total taxa**	**Altitude specificity**				**Type in study area**
		% of altitude specific taxa	**Not specific**	**High**	**Low**	
High altitude plateaus	34	68%	18	34	25	28
Southern part of Kerala (Low altitude)	44	57%	8	26	18	23
Northern part of Karnataka (Low altitude)	34	20%	5	4	12	10
Southern part of Karnataka (Low altitude)	28	24%	3	2	9	3
Total	140	70%	34	66	64	64

Table 7.1: Proportion of herbaceous plant distribution in the study region and few other plateaus studied by various researchers (Based on observation and literature).

Typification: During the course of study, we could observe that few researchers typified few names. For example, *Adenoon indicum* (Bhattacharjee et al., 2016), *Exacum lawii* (Shahina & Nampy, 2016), *Lepidagathis clavata* (Kolte et al.,2016), *Lepidagathis diffusa* (Dhatchanamoorthy et al.,2017), *Utricularia purpurascens* (Janarthanam & Henry, 1984;1992) etc. Also allied species of few endemic taxa are widely distributed. For a few taxon, their close relatives are found in different continents, which were part of the Gondwana Island. They are: (i) *Trithuria konkanensis* only member of the family found in India and all other members of family even allied taxon *T. lanterna* D.A Hook is found in Australian continent (Sokoloff et al.,2011). (ii) Allied taxon of *Wiesneria triandra* (Lehtonen,2009) is from Tropical Africa to Botswana and (iii) Allied taxon of *Blyxa mangalensis* is found in West Africa (Cook and Ruth,1983).

Habitat specificity: In this entire study, it is very clear that the distribution and abundance of species is fundamental. Same species can occupy more than two types of habitats also. We could recognize the various categories of habitats and species occupying multiple habitats in several study region. Even plateaus with similar kind of geography and experiencing same

pattern of rainfall differs in species composition. Studies by Brown (1984), Rindorf and Lewy (2012), He and Condit (2007) and Sreejith et al., (2016) also justifies this observation.

Plant adaptations:

On the plateaus, harsh environmental circumstances have given rise to a variety of species with a variety of startegies. Plants have a number of features that enable them to overcome many of the challenges given by environmental changes (Kluge et al.,1995; Biedinger et al.,2000; Lekhak & Yadav, 2012). According to Raychaudhuri (1981) & Roy and Griffin (1985) leaching processes remove a large portion of the bases originally present in the rock and soil, thus having a residue rich in iron, aluminium, potash and phosphoric acid. Because root penetration in the compact A horizon of the soil is restricted, moisture retention and organic matter content are both limited. As a result, the predominance of carnivorous and semi-parasitic species on rocky plateaus may be due to acidic soils and low phosphate levels. On rocky plateaus, plants have developed tactics such as poikilohydry, geophytic, therophytic, and hydrophytic species. Observation by Watve (2007;2010), Lekhak & Yadav (2012) justifies that, extreme seasonality in climate as well as microclimate from seasonally wet to dry is responsible for such formations.

Mass flowering: Mass blooming of *Utricularia*, *Eriocaulon*, *Geissapsis*, *Dimeria*, *Ischaemum* are common in the study plateaus. Each taxon has a peak flowering period which lasted at least a specific period of time. Therefore, each phase is very characteristic with particular pattern of coloration of habitats. These plants are called as nurse plants (Franco & Nobel,1989). To attract more pollinators, mass blossoming may be an evolutionary strategy. As a result, they play a crucial role in habitat modification (Jong et al., 1992). Nurse plants have a significant impact on the overall plant species richness, abundance, nutrient cycling, and vulnerability to disturbance on rock outcrops (Lozano et al.,2020). They provide microhabitat heterogeneity in such habitats by allowing new colonization sites to themselves, which allow stressful entry of a higher number of species (Houle & Philips,1989; Porembski et al.,1997). Despite the fact that most taxa grow in a variety of microhabitats, population of each species is controlled by dominant species of that particular habitat (Watve,2013).

Seasonal turnover of herbaceous communities: During the monsoon season in the research location, mesic and milder microclimatic conditions resulted in the development of short-lived annuals. The availability of water, which is clearly limited in the region due to long hot dry spells (up to six months), creates a favourable setting for this development. Plants often

experience two distinct temporal events when water and thus nutrients are a limiting resource: a relatively resource-rich pulsed monsoon phase during which most uptake and growth occurs, and a longer inter-pulse phase when water availability is too low for most plants to uptake and during which most mortalities occur. Species occurrence and replacement occur rapidly during the intense monsoon phase.

So far, grassland succession studies have primarily focused on analysis of four pre-determined successional stages: pioneer weeds, annual grass, bunch grass, and mature prairie (Booth,1941; Perino & Risser,1972; Kaputska & Moleski,1976). However, the systematic occurrence of plants during monsoon phases has never been documented by single-site analysis. The intervening vegetation changes during the development from pioneers to grasses occur in a highly variable pattern. However, our results from different plots agree with the predictions that grassland succession is difficult to predict Glen-Lewin (1980), Grime (1973;1979). Also, it is concluded that the species which thrive in harsh conditions are therefore superior competitors under the given resource conditions. Competition is therefore an important process affecting the growth of individuals and also explaining the distribution and abundance of individuals in varied favourable and unfavourable environments (Tilman,1985).

During succession, changes in community structure per plot revealed evident trends. Furthermore, obtained data was more than adequate for understanding the concept. A small sample area was surveyed on these plots owing to the difficulty in measuring several subsequent trends. We have noticed following important features during field study:

1) Number of individuals and species vary in each site.

2) The pioneer herbaceous plants germinate extensively during July-August and then decrease drastically.

3) Temporary ponds showed maximum frequency and abundance in each phase till declining stage.

4) Mid successional stages had greater number of species than other phases.

5) A few late successional species were abundant and they had critical role in succession.

Effect of invasive weeds: The results of weed infected plots revealed that the number of native species in a quadrat decreased significantly with the increase in weed cover (Figure

6.3), there by indicating the negative effect of *Spigelia anthelmia* and *Cassia tora* density on associated native species. A comparison of the quadrat communities between the lowest grade (Grade I) and highest grade (Grade IV) of weed infestation showed a significant reduction of species richness, diversity and evenness from the lowest to the highest infestation grades. This study further revealed that the number of native macrophyte species was significantly lower at highest (Grade IV) weed infestation than that at lowest infestation (Grade I). The presence of multiple invaders in weed infested region is also reported, indicating probable facilitative interactions between various invasive species.

Studies by Anindita and Anjana (2004) on the quadrat communities between the lowest grade (Grade I) and highest grade (Grade IV) of *Alternanthera philoxeroides* infestation showed a significant reduction of species richness, diversity and evenness from the lowest to the highest infestation grades. Some of the characteristics of invasive plants which are responsible for their strong impact on native plant communities are vigorous growth, dense rhizomatous structures, homogenous strands and high cover (Hejda et al., 2009). All of these findings are satisfied by *Spigelia anthelmia* and *Cassia tora*.

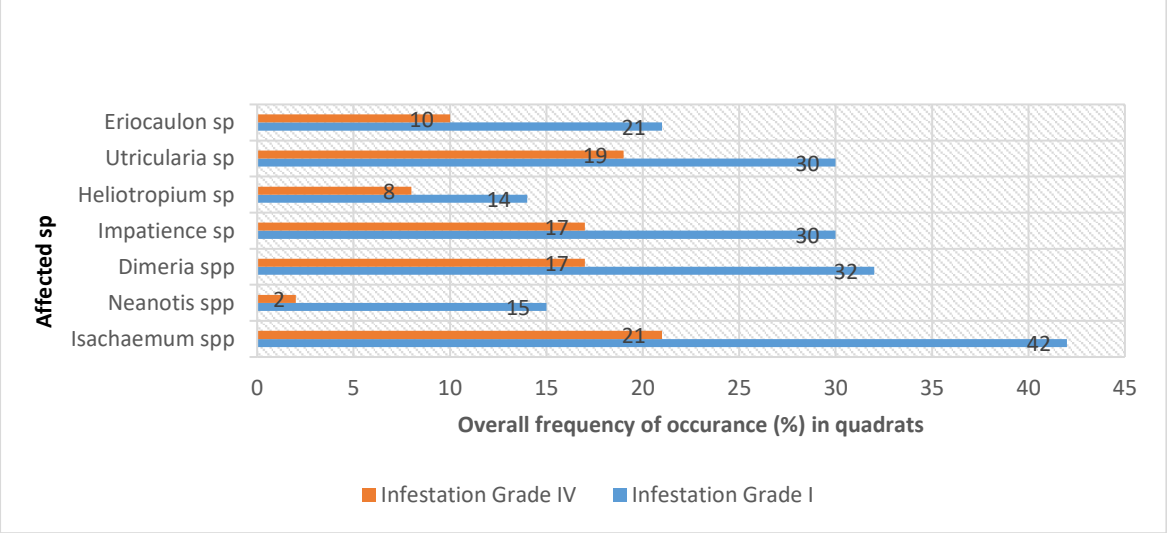


Figure 7.2: Overall frequency of occurrence (%) of native associated flora across the lowest (Grade – I) and highest (Grade –IV) of weed infestation.

Phenological variations: When we have used Multivariate technique of canonical analysis, which shows a clear relationship of group of plants with environmental conditions like humidity, rainfall and temperature predominantly exists. Intensity of rainfall and temperature plays a determining role in the distribution of different species. Eigen value reveals that 64%

of the species mainly depends on rain fall and 34 % of the species mainly depends on Temperature conditions (Fig. 6.4).

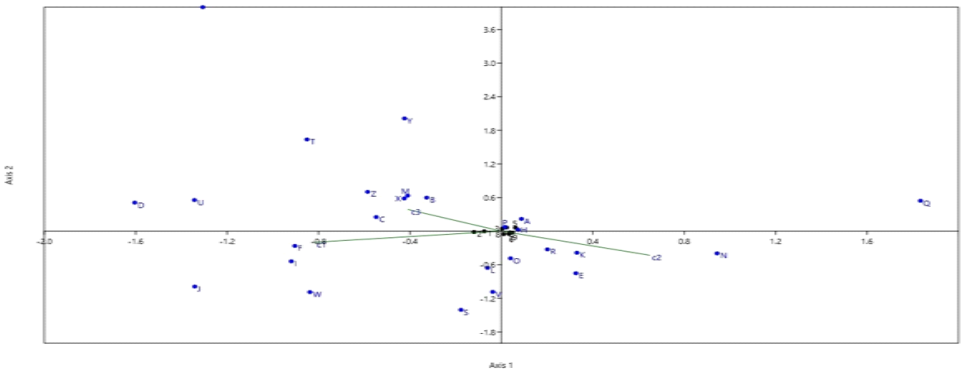


Figure 7.3: Canonical analysis of flowering phenology of selected plant species in relation with humidity, rainfall and temperature fluctuations. Note: C1=Rain, C2=Temperature, C3=Humidity.

This expected response does fit patterns previously established in the literature; although some studies suggest that late-season plants may delay flowering times with warming temperatures (Tilman & Downing,1994; Joshi and Janarthanam, 2004; Sherry, 2007). Based on our observation it is very clear that flowering phenology of herbaceous plant varies in each plateau depending on the microhabitat condition, associated species composition, soil topography and intensity of rain fall etc. Few researches conducted by Shivaraj and Krishnamurthy (1989), Joshy and Janarthanan (2004), Nakar and Jadeja (2015) justifies this observation. Also, there are few studies available which proves that it is difficult to prove the relationship between climatic factors and flowering (Dahlgren et al.,2007; Molau,1997).

According to Shivaraj and Krishnamurthy (1989), Bhat and Murali (2001), Uppal and Singh (2013), Duraisamy and Paulsamy (2010), Pandey and Tripathi (2007) changes in day length, soil moisture and temperature are fundamental in triggering flowering phenology. Ramesh & Pascal (1991; 1997) observed that distribution of species depends on the duration of monsoon rather than amount of rainfall and the drier periods of grassland plateaus provide suitable conditions for maintenance of herbaceous taxa. Present study also justifies this observation.

In the present study only during 2010–11 there was significant negative association between minimum temperature and percentage of species in fruiting. Thus, low temperature leads to less fruiting period. Sundarapandian et al., (2005), Krishnan (2002) also obtained negative correlation between rainfall and flowering phenology. Amjad et al., (2013) concluded that, there was difference in reproductive phenology of 55 herbs i.e. flowering occurs during April–May in dry season, but peak is seen during May–June. This differences in the result

may be due to selection of plant species. The climatic conditions of their study region are different thus giving a different result.

Though there is direct correlation between number of flowering and fruiting days with climatic factors; they are significantly observed during the study period. First flowering days and fruiting days showed significant variation ($P < 0.01$) for few species. Different peaks seen during different seasons for flowering and fruiting governed adaptive mechanisms. To further understand the phenological sequence of habitat-specific species on different plateaus, more research is needed. Environmental fluctuations influenced the flowering periods of all plants in our dataset, but only a few species showed significant responses.

SUMMARY AND CONCLUSION

It has been noted that grassland plateaus differ completely from their surrounding vegetation in both physiognomy and floristic aspects. There are several names of the places across the study region, which have the word 'Padavu', 'Adka' or 'Para', evidently suggesting their geographic features. Example: Maniyampara/ Kottapara in Kerala, have laterite rocks, Hiriyadka in Udupi district has rich plain grasslands. Kasaragod gets its name due to abundance of *Stychnos nux-vomica* (Kasarakana) plants in laterite grasslands. In Karnataka, laterite rocks are called 'Paade' (tulu) or 'Pare' (Kan). The expanse of such grassland plains is called 'Padavu' or 'Adka'.

We have conducted quantitative and qualitative studies which are mainly based on the field investigations. Field work was carried out in different grassland plateaus of southern coastal areas of Kerala and Karnataka states. Our research aims to uncover the bio diversity of the most underestimated ecosystem, along with its ecological and social significance. Madayipara and Bhatkal showed high species diversity followed by Konaje plateau. Also, comparing taxa with allied taxa has resulted in, describing two new taxa *Eriocaulon gopalakrishnanum* (Rashmi and Krishnakumar, 2012) and *Blyxa mangalensis* (Rashmi and Krishnakumar, 2017), a new variety *Eriocaulon lanceolatum* var. *bhatkalense* (Rashmi and Krishnakumar, 2021) and *Hedyotis kurzii* (Rashmi and Krishnakumar, 2015), a new report to Peninsular India.

Of the laterite rich grassland flora, 40% had no component of rarity (i.e., they were not rare in any way), while among the 60% were habitat specific in one or more ways.

Also, species rarity could occur in three different ways:

1) Restricted geographic distribution – 40% had restricted geographic range.
2) Narrow habitat distribution-34% narrow habitat specificity.
3) Low local population abundance-26 % had low population size.

From the principal component analysis (PCA), the prime factors influencing the grassland vegetation are endemism and habitat specificity of plants. Systematic study of plateaus representing maximum rare and endemics, it was clear that important plant species distribution require association of different types of microhabitats in their close proximity.

Threats to the low altitude plateaus as follows:

a. Over exploitation

Some of these places like Madayikkavu, Mujungavu and Ananthapura are famous religious stations. In Kasaragod and Dakshinakannada, more people are visiting these places. The housing complexes, mining areas, and road building are all prevalent.

b. Lack of intensive and extensive exploration

When compared to higher categories of plants, herbaceous flora receives very little attention in India. Botanists have given up on low-altitude grassland plants since they are highly seasonal and complete their life cycle in a matter of days. So, lack of proper knowledge about this group may lead to loss of genetic diversity.

In the studied area, ethnopractice has dramatically decreased. The traditional expertise that previously flourished in the area has no descendants. Firstly, most of the younger generation has migrated to cities in search of livelihood. Secondly, the practitioners of the traditional knowledge decline to share their experience fearing that it may either be misused or their healing powers may come down.

c. Exotic invasion

The possibility of invasion by exotic species like *Alternanthera sessilis*, *Calyptocarpus viralis*, *Senna tora*, *Spigelia anthelmia*, *Synedrella nodiflora* that inadvertently get transported from the sand brought for building construction and also by vehicle tires.

d. fire

During February to March, fire catch is common. This phenomenon leads to destruction of flora and fauna.

e. Afforestation programmes

Bhatkal, Konaje, Mudipu and Valachil plateaus are affected by tree plantations. Due to this, growth of native herbaceous flora is hindered.

Grassland biodiversity is badly neglected, despite its great medicinal, ecological, nutritional, and cultural values. As a result, existing species diversity should be investigated for resource evaluation, conservation and potential domestication. In India, laterite landscapes receive no protection and are considered as drylands.

Since habitat restoration is not possible in this case, the study makes few major recommendations:

- **Conservation of habitat:** For habitat conservation, areas of maximal distribution of narrow endemics must be identified. In species-rich places like the Bhatkal and Madayipara plateaus, conservation sites should be declared.

- Conserving ‘Pallam’ will be the best choice to protect the water table.
- **Conservation of species:** Legal protection for highly threatened taxa and declaring species rich plateaus as an important in-situ conservation site.
- Surangas are used by certain villagers to meet their drinking water demands. As a consequence, promoting awareness about the importance of preserving these historic water gathering structures should be considered.
- The forest department can implement strategies for ecosystem conservation by recognising the plateaus as reserve forests and eco sensitive zones.
- Involving local communities in conservation, monitoring, sensitization towards ecosystem services.
- Through scientific enumeration of the flora and the implementation of experimental research projects, scientists can raise awareness and contribute to scientific understanding of habitats.

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ANNEXURES

Annexure 1: Check list of herbaceous plants from LRO's of study area: *-Endemic to Western Ghats; Cn-S: Conservation Status- LC: Least concern, R: Rare, E: Endemic, Endj: Endangered, CR: Critically endangered.

SL. No	Family	Name of taxa	Local name	R-LF	Flowering phenology	Microhabitats	Cn-S	Phytogeographic distribution
1.	Acanthaceae	*Asystasia dalzelliana* Santapau.	Tulu, Mal: Maithal	C	Nov.-Oct.	V.a, II. b		India
2.	Acanthaceae	*Asystasia gangetica subsp. micrantha* (Nees) Ensermu	Kan: Lavangavalli	C	Nov.-Oct.	V.a.		Africa, India and Sri Lanka
3.	Acanthaceae	*Dicliptera paniculata* (Forssk.) I. Darbysh.	Mal: Kaatupuzhukkoli	C	Sept.-Nov.	V.b		India
4.	Acanthaceae	*Dipteracanthus prostratus* (Poir.) Nees	Mal: Thuppalampotti	C	Jun.-Oct.	V.a, V. b		Tropical & Subtropical Asia
5.	Acanthaceae	*Pseuderanthemum malabaricum* (C.B. Clarke) Gamble		C	Sept.-Nov.	VI.a		India, Sri Lanka
6.	Acanthaceae	*Justicia betonica* L.	Mal: Vellakurinji	C	Aug.-Sept.	Vc, VI. a		Tropical & Subtropical Asia
7.	Acanthaceae	**Justicia ekakusuma* Pradeep & Sivar.		C	Aug.-Sept.	V.d.	T	Western Ghats
8.	Acanthaceae	*Justicia procumbens* L.	Kan: Huchchu Nelabevu	C	Jun.-Sept.	V.a, II. a		India
9.	Acanthaceae	*Justicia serpyllifolia* Gamble		C	Jun.-Sept.	V.d		India
10.	Acanthaceae	*Lepidagathis cuspidata* Nees	Kan: Paare mullu	C	Nov.-Jan.	II.a.		India
11.	Acanthaceae	*Lepidagathis incurva* Buch. -Ham. ex D. Don	Kan: Paare mullu	C	Nov.-Mar.	V.a		Tropical & Subtropical Asia
12.	Acanthaceae	**Lepidagathis keralensis* Madhus. & N.P. Singh	Kan: Paare mullu, Mal: Para mullu, Tul: Paade mullu	C	Aug.-Oct.	II.a.		Western Ghats
13.	Acanthaceae	**Lepidagathis prostrata* Dalzell	Kan: Paare mullu, Mal: Paramullu, Tul: Paade mullu	C	Nov.-Mar.	II.a.		Western Ghats
14.	Acanthaceae	**Lepidagathis clavata Dalzell*	Kan: Paare mullu, Mal: Paramullu, Tul: Paade mullu	C	Oct.-Jun.	V.c		Western Ghats
15.	Acanthaceae	*Rostellularia procumbens* (L.) Nees		C	Aug.-Oct.	V.a, II. b	LC	Asia to Central China

16.	Acanthaceae	*Rungia pectinata* (L.) Nees	Mal: Cheruppu chedi	C	Always	IX.a, V. a		Tropical & Subtropical Asia.
17.	Alismataceaee	**Wiesneria triandra* (Dalzell) Mich.		T	Jun.-Oct.	III	T	Western Ghats
18.	Amaranthaceae	*Achyranthes aspera* L.	Kan: Uttarane	H	Jun.-Oct.	IX.b, V. a		Asia, Africa
19.	Amaranthaceae	*Achyranthes bidentata* Blume	Kan: Kaadu Uttarani	H	Jun.-Oct.	IX.b		India, Nepal, China, and Japan
20.	Amaranthaceae	*Aerva lanata* (L.) Juss.	Kan: Bili sooli	H	Sept.-Mar.	IX.b		Asia, Africa
21.	Amaranthaceae	*Alternanthera pungens* Kunth	Mal: Thevadiyaal mool	H	Oct.-Apr.	IX.b		Central and South America
22.	Amaranthaceae	*Alternanthera sessilis* (L.) R.Br. ex DC.	Kan: Hoangonne	H	Jun.-May.	IX.b, V. a	LC	Sri Lanka and Asia
23.	Amaranthaceae	*Amaranthus spinosus* L.	Kan: Mullu harive	H	Jun.-Mar.	IX.b		Asia
24.	Amaranthaceae	*Amaranthus viridis* L.	Kan: Kaadu harive	H	Jun.-Mar.	IX.b		Africa
25.	Amaranthaceae	*Celosia argentea* L.	Mal: Kozhipoovu	H	Sept.-Mar.	IX.b, II. b	LC	India and China
26.	Amaranthaceae	*Celosia spicata* Spreng.	Kan: Koli juttu	H	Sept.-Mar.	II.b		Asia, Africa
27.	Amaranthaceae	*Gomphrena celosioides* Mart.	Mal: Neervadamalli	H	Jul.-Oct.	IX.b, II. b		Argentina, Bolivia, Brazil, Ecuador
28.	Amaryllidaceae	*Crinum lorifolium* Roxb.		CR	Sept.-Oct.	VI.a	LC	India to Myanmar
29.	Amaryllidaceae	*Pancratium triflorum* Roxb.	Mal: Kaattulli	CR	Apr.-Sept.	VI.a		India
30.	Apiaceae	*Centella asiatica* (L.) Urb.	Kan: Thimare	CR	Aug.-Nov.	IX.b	LC	Asia
31.	Araceae	*Amorphophallus bulbifer* (Roxb.) Blume		CR	Apr.-Sept.	V.c, VI. a		India
32.	Araceae	*Arisaema murrayi* (J. Graham) Hook.	Mal: Pamucholam	CR	Jun.-Sept.	V.d, VI. a		India and Nepal
33.	Araceae	**Arisaema tortuosum* var. *neglectum* (Schott) Fisch.		CR	Jun.-Sept.	VI.a.		Western Ghats
34.	Araceae	*Arisaema tortuosum* (Wall.) Schott.	Kan: Amu manigida	CR	Sept.-Nov.	VI.a		S. Central China

35.	Araceae	**Ariopsis peltata* Nimmo.	Kan: Pare kesu	CR	Jun.-Sept.	VI.a		Western Ghats
36.	Araceae	*Cryptocoryne spiralis* (Retz.) Fisch. ex Wydler		CR	Sept.-Oct.	IV.b		S. & E. India, Bangladesh
37.	Araceae	*Remusatia vivipara* (Roxb.) Schott	Kan: Mara kesu	CR	Jul.-Sept.	VI.a, epiphyte		Central and Western Africa and Asia
38.	Asclepiadaceae	**Ceropegia attenuata* Hook.		CR	Jul.-Sept.	V.a, II. b		Western Ghats
39.	Asclepiadaceae	**Ceropegia jainii* Ansari & B.G.P. Kulk.	Eng: Lantarn flower	CR	Sept.-Oct.	V.a, II. b		Western Ghats
40.	Asteraceae	*Acanthospermum hispidum* DC.	Kan: Kadle mullu	T	Jun.-Oct.	IX.b		South Amrica
41.	Asteraceae	**Adenoon indicum* Dalzell		T	Aug.-Nov.	V.a, V.c		Western Ghats
42.	Asteraceae	*Acmella paniculata* (Wall.ex DC.) R.K. Jansen	Vern: Akkalgaro	T	Aug.-Feb.	IX.b	LC	Tropical and sub tropical parts of the world
43.	Asteraceae	*Ageratina adenophora* (Spreng.) R.M. King & H. Rob.		T	Mar.-Apr.	VII, IX.b		Mexico and Central America
44.	Asteraceae	*Ageratum conyzoides* (L.) L.	Mal: Murianpachcha	T	Jun.-Oct.	IX.b	LC	Tropical America, especially Brazil
45.	Asteraceae	*Artimisia nilagirica* (C.B. Clarke) Pamp.	Kan: Pachapatre	T	Sept.-Jan.	IX.b, IV		China and N. Myanmar
46.	Asteraceae	*Blumea eriantha* DC.		T	July. -Sept.	V.a		Asia
47.	Asteraceae	*Blumea malcolmii* Hook.f.		T	Sept.-Oct.	V.a		India
48.	Asteraceae	*Blumea membranacea* DC.		T	Aug.-Dec.	V.a		Asia
49.	Asteraceae	*Blumea oxyodonta* DC.		T	Oct.-Dec.	II.a, V.c		China and Indo-China
50.	Asteraceae	*Bidens pilosa* L.	Mal: Mukutti	T	Sept.-Nov.	IX.b		Eurasia, Africa, Australia, So uth America and the Pacific Islands
51.	Asteraceae	*Calyptocarpus viralis* Less.		T	Aug.-Nov.	IX.b		Tropical America, especially Brazil
52.	Asteraceae	*Cyanthillium cinereum* (L.) H. Rob.	Mal: Poovamkurunnil a	T	Jun.-Aug.	VI.a		Tropical Africa and to tropical Asia
53.	Asteraceae	*Epaltes divaricata* (L.) Cass.		T	Aug.-Oct.	V.e	LC	Americas, Asia, and Africa
54.	Asteraceae	*Eclipta prostrata* (L.) L.	Kan: Garga	T	Jun.-Sept.	IX.b	LC	India, Nepal, China, Thailand, and Brazil.

55.	Asteraceae	*Elephantopus scaber* L.	Mal: Aanayadi	T	Jun.-Sept.	II.b, VII		tropical Africa and Latin America
56.	Asteraceae	*Emilia sonchifolia* (L.) DC. ex DC.	Mal: Muyal chevi	T	Aug.-Oct.	II		Asia
57.	Asteraceae	*Grangea maderaspatana* (L.) Poir.	Eng: Madras carpet	T	Dec.-may.	IX.b	LC	India and Nepal
58.	Asteraceae	*Sphagneticola trilobata* (L.) Pruski		T	Jun.-Oct.	IX.b		Mexico, Central America
59.	Asteraceae	*Synedrella nodiflora* (L.) Gaertn.	Mal: Mudiyendrapachcha	T	Jun.-Nov.	IX.b		Asia, northern Australia
60.	Asteraceae	*Tridax procumbens* (L.) L.	Kan: Addige soppu; Mal: Chiravanak	T	Jun.-Oct.	IX.A, II.b, V.a		India, America
61.	Asteraceae	*Tricholepis glaberrima* L.	Kan: Brahmadande	T	Jun.-Oct.	VII		India
62.	Asteraceae	*Vernonia cichoriiflora* Chodat		T	Jun.-Sept.	IX.b		Paraguay
63.	Balsaminaceae	*Impatiens acaulis* Arn.		CR	Jun.-Sept.	VI.a		South India, Sri Lanka
64.	Balsaminaceae	*Impatiens balsamina* L.	Kan: Karna kundela	T	Oct.-Feb.	VII		India and Myanmar
65.	Balsaminaceae	*Impatiens minor* (DC.) Bennet	Kan: Neer kaddi, Sone gida	T	Jun.-Sept.	I, II, V.a, VI		Peninsular India
66.	Balsaminaceae	*Impatiens oppositifolia* L.	Kan: Karna kundala	T	Jun.-Sept.	IV.a, I. a		Western Ghats, Sri Lanka
67.	Balsaminaceae	**Impatiens pulcherrima* Dalzelii Hook.F.&Thomson	Kan: Karna kundala	T	Jun.-Sept.	V.b, III.c		Western Ghats
68.	Begoniaceae	*Begonia crenata* Dryand.		T	Aug.-Sept.	VI.a		S. India, Myanmar
69.	Begoniaceae	**Begonia malabarica* Lam.		T	Aug.-Sept.	VI.a.		Western Ghats
70.	Boraginaceae	*Coldenia procumbens* L.		T	Aug.-Apr.	V.e	LC	Africa, through Asia to Australia.
71.	Boraginaceae	*Heliotropium indicum* L.	Mal: Thelkada	T	Jun.-Oct.	V.e	LC	Asia
72.	Boraginaceae	*Heliotropium marifolium* J. Koenig ex Retz.		T	Sept.-Nov.	V.e		India to Hainan and Peninsula Malaysia.
73.	Burmanniaceae	*Burmannia coelestris* D. Don.	Marathi: Neelamani	T	Jul.-Aug.	II.B	LC	Indo-malasia
74.	*Caryophyllacea*	*Polycarpaea corymbosa* (L.) Lam.	Mal: Paade poo	T	Oct.-Jan.	II.a		Tropical & Subtropical

	e							America, Asia
75.	*Caryophyllacea e*	*Polycarpon prostratum* (Forssk.) Asch. & Sehweinf.		T	Aug.-Nov.	V.b	LC	Paleotropics
76.	Cleomaceae	*Cleome viscosa* L.	Ka: Nayibela	T	Jun.-Oct.	IX.b, V. b		Americas, Africa and Asia
77.	Ceasalpineaceae	*Senna occidentalis* (L.) Link	Kan: Aanechogate	T	Jul.-Aug.	V.b	LC	Tropical & Subtropical America
78.	Ceasalpineaceae	*Senna tora* (L.) Roxb.	Kan: Chagathe; Tulu: Thajank	T	Jul.-Aug.	IX.b		Native of South America
79.	Colchiaceae	*Gloriosa superba* L.	Kan: Gowri hoovu	CR	Oct.-Dec.	VIII.a	LC	Paleotropics
80.	Colchicaceae	*Iphigenia indica* (L.) A. Gray ex Kunth	Kan: Neeru baale	T	Aug.-Oct.	V.a, VII		Indo-Malesia to Australia
81.	Colchicaceae	**Iphigenia pallida* Baker.		CR	Aug.-Oct.	V.a, VII		Western Ghats
82.	Commelinaceae	*Commelina bengalensis* L.		T	July-Dec.	V.a, V.b, VI.a, VII	LC	southern India, Sri Lanka
83.	Commelinaceae	*Commelina forskaolii* Vahl.		T	July-Feb.	V.a, VI.a, VII		Africa, Arabia, and India
84.	Commelinaceae	*Commelina undulata* R.Br.		T	Jun.-Sept.	V.a, VII		Sri Lanka and India
85.	Commelinaceae	*Commelina maculata* Edgew.		T	Aug.-Nov.	V.a, VII		China and India
86.	Commelinaceae	*Commelina paludosa* Blume		T	Jun.-Sept.	V.a, VII		Subtropical Asia
87.	Commelinaceae	*Cyanotis tuberosa* (Roxb.) Schult. & Schult.f.		T	July-Dec.	V.a, V.b, V.c	LC	India, Sri Lanka
88.	Commelinaceae.	*Cyanotis fasciculata* (B. Heyne ex Roth) Schult. & Schult.f.		T	Aug.-Oct	V.a, II.a, II. b	LC	Brazil
89.	Commelinaceae	**Cyanotis papilionacea* Schult.		T	Jun.-Aug.	V.a, II.a.	LC	Western Ghats
90.	Commelinaceae	*Murdannia crocea* (Griff.) Faden		T	Jul.-Oct.	V.a, II.a, VI.a.	LC	S. India, Andaman and Nicobar Islands, Myanmar
91.	Commelinaceae	**Murdannia dimorpha* (Dalzell) G. Brückn.		T	Jul.-Sept.	V.a, II.a. VI.a.		Western Ghats
92.	Commelinaceae	*Murdannia nudiflora* (L.) Brenan		T	Jul.-Oct.	V.a, V.c.		Subtropical Asia to W. Pacific

93.	Commelinaceae	**Murdannia semiteres* (Dalzell) Santapau		T	Jul.-Sept.	V.a, V.c	LC	Western Ghats
94.	Commelinaceae	*Murdannia versicolor* (Dalz.) Brukn.		T	Jul.-Oct.	V.a, II.b.		India
95.	Convolvulaceae	*Evolvulus alsinoides* (L.) L.	Kan: Vishnukanthi	C	Jul.-Oct.	V.d.		Australia
96.	Convolvulaceae	*Evolvulus nummularius* (L.) L.		C	Jul.-Oct.	V.d.		North and South America
97.	Cyperaceae	*Cyperus michelianus* (L.) Delile		T	Aug.-Sept.	IV, V. e		India, China, Thailand
98.	Cyperaceae	*Cyperus pangorei* Rottb.		T	Jun.-Sept.	III, IV, V.c		Pakistan to S. China and Sri Lanka
99.	Cyperaceae	*Fimbristylis tenera* Roem. & Schult.		T	Aug.-Dec.	V.e		Worldwide
100.	Cyperaceae	*Fimbristylis tetragona* R. Br.		T	July-Feb.	V.e	LC	Tropical & Subtropical Asia to N. Australia
101.	Cyperaceae	*Fimbristylis woodrowii* C.B. Clarke.		T	Aug.-Oct.	III.c		SE. Pakistan to W. India
102.	Cyperaceae	*Kyllinga brevifolia* Rottb.		T	Aug.-Oct.	V.a	LC	America
103.	Cyperaceae	*Kyllinga nemoralis* (J.R. Forst. & G. Forst.) Dandy ex Hutch. & Dalziel		T	Aug.-Oct.	V.a	LC	Worldwide
104.	Cyperaceae	*Pycreus macrostachyos* (Lam.) J. Raynal		T	Jun.-Dec.	III.b	LC	Madagascar
105.	Cyperaceae	*Pycreus sanguinolentus* (Vahl) Nees ex C.B. Clarke		T	Jun.-Sept.	V.e, V.c	LC	Asia and Africa
106.	Cyperaceae	**Rhynchospora wightiana* (Nees) Steud.		T	Aug.-Sept	VII		Western Ghats
107.	Cyperaceae	*Schoenplectiella articulata* (L.) Lye		T	Aug.-Dec.	III.b		Asia and Africa
108.	Cyperaceae	*Scleria laterifolia* (J.F. Gmel.) Lye		T	Aug.-Dec.	V.e	LC	Asia and Africa
109.	Cyperaceae	*Scleria lithosperma* (L.) Sw.var.*lithosperma*		T	Aug.-Oct.	VII	LC	Asia and Africa
110.	Droseraceae	*Drosera burmanni* Vahl.		T	Jun.-Sept.	V.b	LC	Worldwide
111.	Droseraceae	*Drosera indica* L.	Kan: Hula hiduka	T	Jun.-Sept.	V.b	LC	Asia to Africa
112.	Eriocaulaceae	**Eriocaulon cheemenianum* Biju and Subr.		T	Aug.-Sept.	V.a		Western Ghats

113.	Eriocaulaceae	*Eriocaulon cinerum* R.Br.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	IV.b	LC	India
114.	Eriocaulaceae	**Eriocaulon cuspidatum* Dalzell.		T	Aug.-Sept.	III.a, V.e, IV.a, IV. b	LC	Western Ghats
115.	Eriocaulaceae	*Eriocaulon eurypeplon* Körn.	Kan: Maple toppi	T	Aug.-Sept.	I.a, I.b, II.a, II.b, VI.a, III.c	LC	Peninsular India
116.	Eriocaulaceae	**Eriocaulon gopalakrishnanum* K. Rashmi & G. Krishnak	Kan: Maple toppi	T	Aug.-Sept.	V.d, V. b		Western Ghats
117.	Eriocaulaceae	**Eriocaulon heterolepis* Steud.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	III.a		Western Ghats
118.	Eriocaulaceae	**Eriocaulon lanceolatum* Miq. ex Körn.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	V.d	LC	Western Ghats
119.	Eriocaulaceae	**Eriocaulon lanceolatum* var. *bhatkalense*		T	Aug.-Sept.	V.b, V. a		Western Ghats
120.	Eriocaulaceae	**Eriocaulon fysonii* R. Ansari & N.P. Balakr.		T	Aug.-Sept.	V.e	LC	Western Ghats
121.	Eriocaulaceae	**Eriocaulon madayiparense* Remya and Sunil	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Oct.	V.e		Western Ghats
122.	Eriocaulaceae	**Eriocaulon parviflorum* (Fyson) R. Ansari & N.P. Balakr.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	IV.a	LC	Western Ghats
123.	Eriocaulaceae	**Eriocaulon odoratum* Dalzell	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	V.a	LC	Western Ghats
124.	Eriocaulaceae	**Eriocaulon richardianum* (Fyson) R. Ansari & N.P. Balakr.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Oct.	III.b, IV. b	EN	Western Ghats
125.	Eriocaulaceae	**Eriocaulon robustobrownianum* Ruhland.	Kan: Betta gundu, Mal: Maple thoppi	T	Aug.-Sept.	V.d, II.b	LC	Western Ghats
126.	Eriocaulaceae	**Eriocaulon stellulatum* Körn.	Kan: Betta gundu, Mal: Maple thoppi	T	Sept.-Feb.	V.d.	LC	Western Ghats
127.	Eriocaulaceae	*Eriocaulon xeranthemum Mart.*	Kan: Betta gundu, Mal:	T	Sept.-Feb.	V.b	LC	India

			Maple thoppi					
128.	Euphorbiaceae	*Acalypha indica* L.	Kan: Kuppi gida	T	Jun.-Oct.	IX.b		Indo Malasia and Tropical Africa
129.	Euphorbiaceae	*Acalypha paniculata* Miq.		T	Jun.-Oct.	IX.b		Indo Malasia and Tropical Africa
130.	Euphorbiaceae	**Euphorbia katrajensis* Gage.		T	Jun.-Oct.	II.a, VI. b		Western Ghats
131.	Euphorbiaceae	**Euphorbia notoptera* Boiss.		T	Aug.-Apr.	II.b, VI. b		Western Ghats
132.	Euphorbiaceae	*Euphorbia heterophylla* L.		T	Jul.-Oct.	V.a, VI. b		Native of Central America
133.	Euphorbiaceae	*Euphorbia hirta* L.	Kan: Hachche gida	T	Jun.-Oct.	II.a, III.c		Native of tropical America
134.	Euphorbiaceae	*Micrococca mercurialis* (L.) Benth.	Mal: Kunukku thooki	T	Jun.-Sept.	IX.b, VI. b		Tropical Africa, Arabia, India, Sri Lanka
135.	Phyllanthaceae	*Phyllanthus urinaria* L.		T	Jun.-Oct.	V.d, VI. b		India
136.	Fabaceae	*Aeschynomene americana* L.		T	Jun.-Oct.	V.d, V.b		Central America
137.	Fabaceae	*Aeschynomene aspera* L.		T	Jun.-Oct.	V.d, V. b		Sri Lanka, Thailand, and Vietnam
138.	Fabaceae	*Alysicarpus bupleurifolius* (L.) DC	Mal: Nir-murri	T	Aug.-Apr.	V.d, V. b	LC	Asia
139.	Fabaceae	*Alysicarpus tetragonolobus* Edgew.		T	July. -Dec.	V.d, V. b		Africa, Asia and Australia
140.	Fabaceae	*Alysicarpus vaginalis* (L.) DC.	Kan: Naamada soppu	T	Jul.-Oct.	V.d, V.a		Australia and the Americas
141.	Fabaceae	*Crotalaria mysorensis* Roth.		T	Oct.-Jan.	V.d, V. a		India
142.	Fabaceae	*Crotalaria quinquefolia* L.	Neeru thagathe	T	Sept.-Nov.	III.b	LC	Jamaica and West Indies
143.	Fabaceae	**Crotalaria filipes* Benth.		T	Jun.-Sept.	IIb		Western Ghats
144.	Fabaceae	*Crotalaria retusa* L.		T	Oct.-Jan.	IIb		Asia, Africa and Australia
145.	Fabaceae	*Derris scandens* (Roxb.) Benth.		T	Jun.-Jul.	IIb	LC	Asia, Malesia and Australasia
146.	Fabaceae	*Desmodium gangeticum* (L.) DC.		T	Sept.-Dec.	VI.a		India
147.	Fabaceae	*Desmodium heterocarpon* (L.) DC.		T	Sept.-Nov.	IIb, VI. a		China, Japan, Indian subcontinent
148.	Fabaceae	*Desmodium scorpiurus* (Sw.) Desv.		T	Jun.-Nov.	IIb, VI. a		Asia

149.	Fabaceae	*Desmodium triflorum* (L.) DC.		T	Jun.-Oct.	II.a, V. a		India
150.	Fabaceae	**Indigofera dalzellii* T. Cooke		T	Jun.-Nov.	V.c, II. b		Western Ghats
151.	Fabaceae	*Indigofera tinctoria* L.	Kan: Neeli gida	T	Aug.-Oct.	V.c, II. b		Asia and Africa
152.	Fabaceae	*Indigofera trifoliata* L.		T	Aug.-Oct.	V.c, II. b		Indo-Malesia, China and Australia
153.	Fabaceae	*Geissaspis cristata* Wight & Arn.		T	Aug.-Oct.	III.c, IV. a	LC	Indian Subcontinent to China (Guangdong) and Peninsula Malaysia
154.	Fabaceae	**Geiasapsis tenella* Benth.		T	Aug.-Oct.	IV.a, IV.c	LC	Western Ghats
155.	Fabaceae	*Smithia conferta* Sm.		T	Jul.-Nov.	II.b		Smithia conferta Sm.
156.	Fabaceae	*Smithia salsuginea* Hance.		T	Sept.-Nov.	II.b		Peninsular India
157.	Fabaceae	*Stylosanthes fruticosa* (Retz.) Alston.		T	Jul.-Oct.	V.d.		Sri Lanka, India, Africa and Madagascar
158.	Fabaceae	*Zornia gibbosa* Span.	Kan: Maddele	T	Jun.-Sept.	V.b, II. b		India
159.	Gentianaceae	*Canscora diffusa* (Vahl) R.Br. ex Roem. & Schult.		T	Jun.-Oct.	I.c, V.d, VI		Africa and Asia
160.	Gentianaceae	*Canscora macrocalyx* Miq.		T	Jun.-Oct.	I.c, II.a, V. a		India
161.	Gentianaceae	**Canscora pauciflora* Dalzell.		T	Jun.-Oct.	V.c, VII		Western Ghats
162.	Gentianaceae	**Canscorinella bhatiana* Subm & Biju (K.S. Prasad & Raveendran) Shahina & Nampy		T	Jul.-Nov.	II.a, V. d		Western Ghats
163.	Gentianaceae	**Canscorinella stricta* (Sedgw.) Nampy and Shahina		T	Jul.-Sept.	II.a		Western Ghats
164.	Gentianaceae	*Exacum lawii* C. B. Clarke		T	Sept.-Dec.	II.a, VII		Western and North-Western borders of the Peninsular plateau
165.	Gentianaceae	*Exacum pedunculatum* L.		T	Sept.-Mar.	II.a, VII		India to Bangladesh, Sri Lanka
166.	Gentianaceae	*Exacum petiolare* Griseb.		T	Dec.-Mar.	II.a, VII		Tanzania to Mozambique
167.	Gentianaceae	*Exacum pumilum* Griseb.		T	Aug.-Dec.	II.a, VII		India
168.	Gentianaceae	*Exacum tetragonum* Roxb.	Kan: Akka tangi gida	T	Aug.-Dec.	II.a, VII		India and China

169.	Gentianaceae	*Exacum sessile* L.		T	Aug.-Sept.	V.a, VII		SW. India, Sri Lanka
170.	Gentianaceae	*Hoppea dichotoma* Willd.		T	Aug.-Sept.	V.a, VII		India
171.	Gentianaceae	*Hoppea fastigiata* (Griseb.) C.B. Clarke.		T	Aug.-Sept.	V.a, VII	LC	South Asia
172.	Hydatellaceae	**Trithuria konkanensis* S.R. Yadav & Janarth		T	Aug.-Sept.	V.b, V. e	LC	Western Ghats
173.	Hydrocharitaceae	*Blyxa aubertii* Rich.		T	Aug.-Dec.	III.a, IV.a, IX. a	LC	Asia, Europe, Africa and Australia
174.	Hydrocharitaceae	*Blyxa echinosperma* (C.B. Clarke) Hook.f.		T	Aug.-Oct.	III.b, IV. b		Widespread
175.	Hydrocharitaceae	**Blyxa kasaragodensis* Biju & Jomy		T	Aug.-Oct.	III.b		Western Ghats
176.	Hydrocharitaceae	**Blyxa mangalensis* Rashmi & Krishnakm.		T	Jul.-Oct.	III.a, IV. a		Western Ghats
177.	Hydrocharitaceae	*Blyxa octandra* (Roxb.) Planch. ex Thwaites		T	Jul.-Dec.	III.a, III.b, IV.a, IV. b	LC	Indo-Malasia and Australia
178.	Hydrocharitaceae	*Ottelia alismoides* (L.) Pers.		T	Jun.-Oct.	IV.b	LC	Asia and Australia
179.	Hypoxidaceae	*Curculigo orchiodes* Gaertn.	Mal: Nelappane	CR	Jun.-Oct.	VI.a, VIII.a		Indo-Malasia
180.	Lamiaceae	*Anisochilus carnosus* (L.f.) Wall.		T	Aug.-Nov.	VI.b.		India
181.	Lamiaceae	*Anisomeles indica* (L.) Kuntze		T	Jul.-Oct.	VI.b.		Eastern Asia
182.	Lamiaceae	*Basilicum polystachyon* (L.) Moench		T	Jun.-Oct.	IX.b		Africa and Indo-Malesia
183.	Lamiaceae	*Leucas biflora* (Vahl) Sm.	Eng: Two flowered leuacas	T	Aug.-Oct.	IX.b		Indian Subcontinent to Indo-China
184.	Lamiaceae	*Leucas linifolia* (Roth) Spreng.	Kan: Thumbe	T	Jun.-Sept.	IX.b		India, New Guinea
185.	Lamiaceae	*Hyptis suaveolens* (L.) Poit.	Kan: Gasagase	T	Oct.-Feb.	IX.b		Africa, Asia and Australia
186.	Lamiaceae	*Ocimum americanum* L.	Kan: Nayi Tulasi	T	Jun.-Oct.	IX.b		Africa, the Indian Subcontinent, China, and Southeast Asia
187.	Lamiaceae	*Plectranthus mollis* (Aiton)Spreng.		T	Jul.-Sept.	IX.b		India, Sri Lanka
188.	Lamiaceae	**Pogostemon deccanensis* (Panigrahi) Press.		T	Aug.-Sept.	V.e		Western Ghats

189.	Lamiaceae	*Pogostemon paniculatus* (Willd.) Benth.		T	Oct.-Feb.	V.a, V. c		Peninsular India and Myanmar
190.	Lamiaceae	*Pogostemon quadrifolius* (Benth.) F. Muell.		T	Sept.-Nov.	V.c	DD	India
191.	Lentibulariaceae	*Utricularia aurea* Lour.		T	Sept.-Nov.	III. b		Asia, Oceania, and Australia
192.	Lentibulariaceae	*Utricularia caerulea* L.		T	Sept.-Nov.	V.e		Asia, Oceania, and Australia
193.	Lentibulariaceae	**Utricularia cecilii* P. Taylor	Mal: Krishnapoovu	T	Aug.-Oct.	V.a, V.e		Western Ghats
194.	Lentibulariaceae	*Utricularia graminifolia* Vahl	Mal: Krishnapoovu	T	Aug.-Oct.	V.a, V.e		Burma, China, India, Sri Lanka, and Thailand
195.	Lentibulariaceae	**Utricularia lazulina* P. Taylor	Mal: Krishnapoovu	T	Aug.-Oct.	V.a, V.e		Western Ghats
196.	Lentibulariaceae	**Utricularia malabarica* Janarth. & A.N. Henry	Mal: Krishnapoovu	T	Aug.-Oct.	I.a, II.a		Western Ghats
197.	Lentibulariaceae	*Utricularia purpurascens*J.Graham	Mal: Krishnapoovu	T	Aug.-Oct.	Ia, V.c, III.c		Asia
198.	Lentibulariaceae	*Utricularia reticulata* Sm.	Mal: Krishnapoovu	T	Sept.-Oct..	III.a	LC	India, Sri Lanka
199.	Lentibulariaceae	*Utricularia striatula* Sm.	Mal: Krishnapoovu	T	Aug.-Sept.	I		Africa to New Guinea
200.	Lentibulariaceae	*Utricularia uliginosa* Vahl	Mal: Krishnapoovu	T	Jul.-Sept.	V.c, III.c	LC	Asia, Oceania, and Australia
201.	Linderniaceae	*Lindernia ciliata* (Colsm.) Pennell		T	Aug.-Oct.	V.b		S.E Asia
202.	Linderniaceae	*Lindernia crustacea* (L.) F. Muell.		T	Aug.-Oct.	V.b		India, S.E Asia
203.	Linderniaceae	*Lindernia hyssopoides* (L.) Haines		T	Aug.-Oct.	V.e		E. Asia
204.	Loganiaceae	*Mitrasacme indica* Wight		T	Jun.-Sept.	V. d		India, Sri Lanka
205.	Loganiaceae	*Spigelia anthelmia* L.		T	Jun.-Oct.	IX.b		America, Africa and Indonesia
206.	Lythraceae	*Ammannia baccifera* L.		T	Sept.-Dec.	V.a		Asia, America and Africa
207.	Lythraceae	**Rotala dhaneshiana* Pradeep, Joseph and Sivaraj.	Mal: Para thamara	T	Jul.-Aug.	IV.a, III.c		Western Ghats

208.	Lythraceae	**Rotala baileyana* RogimonThomas oby Paul, Rameshan, Nisha, Ignatius Antony	Mal: Para thamara	T	Jul.-Aug.	III. b		Western Ghats
209.	Lythraceae	**Rotala kasaragodensis* Prasad & Raveendran	Mal: Para thamara	T	Jul.-Aug.	III. a		Western Ghats
210.	Lythraceae	*Rotala macrandra* Koehne.	Mal: Para thamara	T	Jul.-Aug.	III. a, III.c		Western Ghats
211.	Lythraceae	**Rotala malabarica* A.K. Pradeep, K.T. Joseph & V.V. Sivarajan.	Mal: Para thamara	T	Jul.-Aug.	III. a, III.c	CR	Western Ghats
212.	Lythraceae	**Rotala malampuzhensis* R.V. Nair	Mal: Para thamara	T	Jul.-Aug.	III.a III.c	LC	Western Ghats
213.	Lythraceae	*Rotala rosea* (Poir.) C.D.K. COOK	Mal: Para thamara	T	Jul.-Aug.	III.a, III.c	LC	Malasia, East Asia
214.	Lythraceae	*Rotala rotundifolia* (Buch. -Ham. Ex Roxb.) Koehne	Mal: Para thamara	T	Jul.-Aug.	III.a, IV.a,IV.c	LC	Asia
215.	Lythraceae	**Rotala tulunadensis* K.S. Prasad, P. Biju, Raveendran & K. Gopalakrishna Bhat	Mal: Para thamara	T	Jul.-Sept.	IV.a, IV.c		Western Ghats
216.	Malvaceae	*Abutilon indicum* (L.) Sweet	Mal: Velluram; Kan: Thutti gida	T	Sept.-Apr.	II.b, V.a.	LC	Great Barrier Reef islands of the Coral Sea
217.	Malvaceae	*Melochia corchorifolia* L.	Mal: Seruvurum	T	Feb.-Jun.	II.b, V.a.		North Carolina to Mississippi
218.	Malvaceae	*Urena lobata* L.		T	Jun.-Sept.	II.b, V.a.	LC	Brazil and Southeast Asia
219.	Malvaceae	*Sida acuta* Burm.f.		T	Jul.-Aug.	II.b, V.a.	LC	Central America
220.	Malvaceae	*Sida alnifolia* L.		T	Jul.-Aug.	II.b, V.a.		Africa, Australia
221.	Malvaceae	*Sida mysorensis* Wight & Arn.	Kan: Kallamgadale; Mal: Kurundoti	T	Jul.-Aug.	II.b, V.a.		India, Sri Lanka, South Africa
222.	Malvaceae	*Triumfetta rhomboidea* Jacq.	Kan: Kaadu bende	T	Sept.-Nov.	V.a		China.
223.	Melastomataceae	**Osbeckia muralis* Naudin		T	Sept.-Oct.	V.a, VII		Western Ghats
224.	Melastomataceae	*Sonerila scapigera* Dalzell		T	Jul.-Sept.	V.a, VIII.b		Oriental-S India, Sri Lanka

225.	Meliaceae	*Naregamia alata* Wight & Arn.	Mal: Nilanaragam	C	Jun.-Sept.	V.a		Peninsular India
226.	Menynthaceae	*Nymphoides indica* (L.) Kuntze		CR	Aug.-Oct.	III.b		Tropical & Subtropical Asia to SW. Pacific.
227.	Menynthaceae	*Nymphoides parvifolia* Kuntze		CR	Aug.-Oct.	III.b, III.c		Tropical Asia to N. Australia.
228.	Menynthaceae	**Nymphoides krishnakesara* K.T. Joseph & Sivar.		CR	Aug.-Sept.	III.b.		Western Ghats
229.	Menynthaceae	**Nymphoides krishnakesara* var. bispinosa Biju ,Josekutty,Muhammed Haneef , Jomy Augustine.		CR	Aug.-Sept.	III.b.		Western Ghats
230.	Mimosaceae	*Mimosa pudica* L.	Kan: Thottavaadi; Kan: Naachige mullu	T	Jun.-Sept.	IX.b, V.a		Southern United States, South Asia, East Asia and South Africa
231.	Molluginaceae	*Glinus lotoides* L.		T	Jul.-Sept.	IX.b	LC	Eurasia and Africa
232.	Molluginaceae	*Glinus oppositifolius* (L.) Aug.DC.		T	Jul.-Sept.	IX.b	LC	India, China, Southeast Asia, Australia
233.	Molluginaceae	*Mollugo pentaphylla* L.	Mal: Padappan pullu	T	Jun.-Sept.	V.a		Asia to Australia, New Caledonia and Micronesia
234.	Nyctaginaceae	*Boerhavia diffusa* L.		T	Aug.-Oct.	IX.b		India, the Pacific, and southern United States
235.	Onagraceae	*Ludwigia hyssopifolia* (G. Don) Exell		T	Jun.-Sept.	III.a, III.c		southeast Asia to New Guinea and Australia.
236.	Orchidaceae	*Acampe praemorsa* (Roxb.) Blatt. & McCann.		CR	Sept.-Apr.	V.a, II. b		Tropical & Subtropica, Asia
237.	Orchidaceae	**Aerides crispa* Lindl.		CR	Feb.-Jul.	I.d		Western Ghats
238.	Orchidaceae	**Bulbophyllum rosemarianum* C.S. Kumar, P.C. S		P	Jun.-Sept.	Epiphyte		Western Ghats
239.	Orchidaceae	*Crepedium resupinatum* (G. Forst.) Szlach.		P	Jul.-Sept.	VIII.a		Papua New Guinea to S. Pacific, India
240.	Orchidaceae	*Habenaria diphylla* (Nimmo) Dalzell.		CR	Jul.-Oct.	V.a, II.b		India to Bangladesh and Philippines
241.	Orchidaceae	*Habenaria plantaginea* Lindl.		CR	Jul.-Oct.	V.a, V.d		Sri Lanka, India

242.	Orchidaceae	*Liparis rheedei* Lindl.		T	Aug.-Oct.	VI.a		Western Ghats, Malasia, New Guinea
243.	Orobanchaceae	*Buchnera hispida* Buch. -Ham ex D. Don		T	Aug.-Dec.	Root parasite		India to Bangladesh and Philippines
244.	Orobanchaceae	*Centranthera indica* (L.) Gamble	Mal: Korosinum	T	Sept.-Oct.	Root parasite		India, Bangladesh
245.	Orobanchaceaee	**Parasopubia hofmanni* Pradeep and Pramod.		T	Sept.-Oct.	V.b, IX. b		Western Ghats
246.	Orobanchaceae	**Parasopubia delphinifolia* (L.) H.-P. Hofm. & Eb. Fisch.		T	Sept.-Oct.	V.b, II. a		Western Ghats
247.	Orobanchaceae	*Rhamphicarpa fistulosa* (Hochst.) Benth.		T	Sept.-Oct.	V.a		India
248.	Orobanchaceae	*Sopubia trifida* Buch. -Ham. Ex D. Don		T	Sept.-Oct.	V.b, II. b		S. China to Tropical Asia
249.	Orobanchaceae	*Striga angustifolia* (D. Don) C.J. Saldanha	Mal: Kalu-polapen	T	Aug.-Sept.	Root parasite		India
250.	Orobanchaceae	*Striga asiatica* (L.) Kuntze.	Mal: Kalu-polapen	T	Aug.-Sept.	Root parasite		Asia and sub-Saharan Africa
251.	Orobanchaceae	*Striga gesnerioides* (Willd.) Vatke	Mal: Kalu-polapen	T	Jul.-Sept.	Root parasite		Africa, Asia
252.	Orobanchaceae	*Striga linearifolia* (Schumach. & Thonn.) Hepper	Mal: Kalu-polapen	T	Jul.-Sept.	Root parasite		Africa, Asia
253.	Oxalidaceae	*Oxalis corniculata* L.		T	Jun.-Sept.	V.e		Asia
254.	Oxalidaceae	*Biophytum reinwardtii* (Zucc.) Klotzsch.		T	Aug.-Nov.	V.a.		India
255.	Pedaliaceae	*Pedalium murex* L.		T	Sept.-Oct.	IX.b		India, Sri Lanka and Tropical Africa
256.	Pedaliaceae	*Sesamum radiatum* Schumach. & Thonn.		T	Jul.-Aug.	IX.b		Asia and Africa
257.	Phyllanthaceae	*Phyllanthus airy-shawii* Jean F. Brunel & J.P. Roux		T	Jul.-Sept.	IX.b		Peninsular India and Sri Lanka
258.	Phyllanthaceae	*Phyllanthus amarus* Schumach. & Thonn.	Kan: Nela Nelli	T	Jul.-Sept.	IX.b		America
259.	Phyllanthaceae	*Phyllanthus reticulatus* Poir.		T	Jul.-Sept.	IX.b		East Asia
260.	Phyllanthaceae	*Phyllanthus urinaria* L.		T	Jul.-Sept.	IX.b		India
261.	Plantaginaceae	*Limnophila repens* (Benth.) Benth.		T	Jul.-Aug.	III.b		India, China, Africa
262.	Plantaginaceae	*Dopatrium junceum* (Roxb.) Buch. -Ham ex		T	Jul.-Aug.	III.c	LC	India, Sri Lanka

		Benth						
263.	Plantatginaceae	*Dopatrium lobelioides* (Retz.) Benth.		T	Jun.-Sept.	III.c		South India, Sri Lanka.
264.	Plantaginaceae	*Mecardonia procumbens* (Mill.) Small		T	Jul.-Oct.	V.e		America
265.	Plantaginaceae	*Microcarpaea minima* (Retz.) Merr.		T	July. -Nov.	IX.b		Asia
266.	Plantaginaceae	*Scoparia dulcis* L		T	July. -Nov.	IX.b		India & Bangladesh
267.	Poaceae	*Allopteropsis cimicina* (L.) Staff.		T	Sept.-Nov.	V.a, II. b		India, China, Africa
268.	Poaceae	*Apluda mutica* L.		T	Jul.-Oct.	V.a, II. b		Tropical Asia and Australia
269.	Poaceae	**Apocopis mangalorensis* (Hochst. ex Steud.) Henrard		T	Aug.-Nov.	V.a, II. b		Western Ghats
270.	Poaceae	*Artistida adscensionis* L.		T	Sept.-Dec.	V.a, II.b, II. a		India, South America, Australia
271.	Poaceae	*Arthraxon hispidus* T (hunb.) Makino		T	Aug.-Nov.	II.b, VII		Africa, W. Indian Ocean, Asia to E. Australia
272.	Poaceae	*Arthraxon jubatus* Hack.		T	Aug.-Nov.	V.a, II. b		India
273.	Poaceae	*Arthraxon lanceolatus* (Roxb.) Hochst.		T	Aug.-Nov.	V.a, II. b		India, Nepal, Arabia and China
274.	Poaceae	**Arthraxon meeboldii* Stapf		T	Sept.-Dec.	V.a, II. b		Western Ghats
275.	Poaceae	**Arundinella cannanorica* V.J. Nair, Sreek. & N.C. Nair		T	Sept.-Dec.	V.a, VII.		Western Ghats
276.	Poaceae	*Arundinella leptochloa* (Steud.) Hook.f.		T	Sept.-Dec.	V.a, II. b		India, Sri Lanka
277.	Poaceae	**Arundinella metzii* Hochst. ex Miq.		T	Sept.-Dec.	V.a, II.		Western Ghats
278.	Poaceae	*Arundinella pumila* (Hochst.) Steud.		T	Sept.-Dec.	V.a, VII.		India, Africa, Australia
279.	Poaceae	*Arundinella spicata* Dalzell		T	Sept.-Dec.	V.a, II. b		America
280.	Poaceae	*Axonopus compressus* (Sw.) P. Beauv.		T	Sept.-Dec.	V.a, II. b		Tropica and Subtropics
281.	Poaceae	**Bhidea burnsiana* Bor		T	Aug.-Nov.	II		Western Ghats
282.	Poaceae	*Bhidea fischeri* Sreek. & B.V. Shetty		T	Aug.-Sept.	II		Peninsular India
283.	Poaceae	*Brachiaria reptans* (L.) C.A. Gardner & C.E. Hubb.		T	Aug.-Nov.	V.a, VII.	LC	Tropical Asia

284.	Poaceae	*Chrysopogon castaneus* Veldkamp ex Salunkhe		T	Aug.Oct. T	V.a, II. b		India
285.	Poaceae	**Coelachne madayensis* Pramod & Pradeep.		T	Jul.-Oct.	III.a		Western Ghats
286.	Poaceae	**Coelachne minuta* Bor.		T	Jul.-Oct.	III.a	LC	Western Ghats
287.	Poaceae	*Coelachne simpliciuscula* (Wight et. Arn. ex. Steud.) Munro. ex. Benth.		T	Aug.-Nov.	III.a		Madagascar, S. China to Tropical Asia
288.	Poaceae	**Dichanthium panchganiense* Blatt. & McCann		T	Aug.-Oct.	V.a, II. b		Western Ghats
289.	Poaceae	**Dichanthium oliganthum* (Hochst. ex Steud.) Cope		T	Aug.-Oct.	V.a, II. b		Western Ghats
290.	Poaceae	**Dichanthium paranjpyeanum* (Bhide) Clayton		T	Aug.-Nov.	V.a, II. b		Western Ghats
291.	Poaceae	*Digitaria bicornis* (Lam.) Roem. & Schult.		T	Sept.-Nov.	V.a		Asia to N. Australia
292.	Poaceae	*Digitaria ternata* (A. Rich.) Stapf		T	Sept.-Nov.	V.a, II. b		Ghana, Rhodesia, Asia
293.	Poaceae	**Dimeria bialata C.E.C Fisch.*		T	Oct.-Nov	V.a, II, VII		Western Ghats
294.	Poaceae	**Dimeria deccanensis* Bor		T	Oct.-Nov.	V.a, II, VII		Western Ghats
295.	Poaceae	*Dimeria hohenackeri* Hochst. ex Miq.	Kan: Muli hullu	T	Oct.-Nov.	V.a, II, VII	EN	Peninsular India
296.	Poaceae	*Dimeria lawsonii* (Hook.f.) Fischer		T	Sept.-Nov.	II		Africa, Asia
297.	Poaceae	*Dimeria mooneyi* Raizada ex Mooney		T	Aug.-Nov.	II		Peninsular India
298.	Poaceae	**Dimeria ornithopoda* var. *megalantha* Bor		T	Oct.-Nov.	V.a, II, VII	LC	Western Ghats
299.	Poaceae	**Dimeria ornithopoda* var. *ornithopoda*		T	Sept.-Nov.	V.a, II, VII	LC	Western Ghats
300.	Poaceae	**Dimeria stapfiana* C.E. Hubb. ex Pilg.		T	Aug.-Nov.	V.a, II, VII		Western Ghats
301.	Poaceae	*Echinichloa colona* (L.) Link.		T	Sept.-Nov.	V.e		Africa, Asia
302.	Poaceae	*Elusine indica* (L.) Gaertn.		T	Sept.-Nov.	V.e		S. Africa, S. Arabian Peninsula, Tropical Asia

303.	Poaceae	*Eragrostis indica* Link.		T	Aug.-Nov.	V.a, V.d, II, VI		Asia
304.	Poaceae	*Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult.		T	Aug.-Oct.	V.a, II		Asia
305.	Poaceae	*Eragrostis tenuifolia* (A. Rich.) Hochst. ex Steud.		T	Aug.-Oct.	V.a, II		Africa and South India
306.	Poaceae	*Eragrostis unioloides* (Retz.) Nees ex Steud.		T	Aug.-Oct.	V.a, II	LC	India
307.	Poaceae	*Eragrostis viscosa* (Retz.) Trin.		T	Aug.-Oct.	V.a, II		S. Africa, S. Arabian Peninsula, Tropical Asia
308.	Poaceae	**Garnotia arborum* Stapf		T	Sept.-Nov.	I.a, I.c		Western Ghats
309.	Poaceae	*Garnotia tenella* (Arn. ex Miq.) Janowski		T	Aug.-Nov.	V.a, I.c		Asia
310.	Poaceae	**Glyphochloa acuminata* (Hack.) Clayton		T	Jul.-Oct.	V.a, II. b		Western Ghats
311.	Poaceae	*Glyphochloa divergens* (Hack.) Clayton		T	Sept.-Nov.	V.a, II. b		India
312.	Poaceae	*Glyphochloa forficulata* (C.E.C. Fisch.) Clayton		T	Sept.-Nov.	V.a, II. b		Peninsular India
313.	Poaceae	*Glyphochloa mysorensis* (Jain & Hemadri) Clayton		T	Aug.-Nov.	V.a, II. b		Peninsular India
314.	Poaceae	*Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult.		T	Sept.-Nov.	VII		Africa, Asia
315.	Poaceae	*Heteropogon polystachyus* (Roxb.) Schult		T	Jul.-Jan.	VII		India
316.	Poaceae	*Heteropogon ritchiei* (Hook. f.) Blatt. & McCann		T	Aug.-Nov.	VII		India
317.	Poaceae	*Indopoa paupercula* (Stapf) Bor		T	Aug.-Nov.	II, I.c		India
318.	Poaceae	**Isachne bhatii* Biju&Jomy		T	Jul.-Aug.	V.a, V.e, II.b		Western Ghats
319.	Poaceae	*Isachne bicolor* Naik & Patunkar		T	Aug.-Nov.	V.a, V.e, II.b		India
320.	Poaceae	*Isachne borii* Hemadri		T	Aug.-Nov.	V.a, V.e, II.b		India
321.	Poaceae	*Isachne elegans* Dalzell		T	Aug.-Nov.	V.a, V.e, II.b	LC	India
322.	Poaceae	*Isachne globosa* (Thunb.) Kuntze		T	Jul.-Aug.	V.e	LC	Asia to W. Pacific

323.	Poaceae	*Isachne gracilis* C. E. Hubb.		T	Aug.-Nov.	V.a, V.e, II.b		Peninsular India
324.	Poaceae	*Isachne lisboae* Hook. f.		T	Aug.-Nov.	V.a, V.e, II.b		Peninsular India
325.	Poaceae	*Isachne miliacea* Roth		T	Aug.-Nov.	V.a, V.e, II.b		India, China
326.	Poaceae	**Isachne swaminathanii* V. Prakash & S. K. Jain		T	Sept.-Oct	V.a, V.e, II.b		Western Ghats
327.	Poaceae	**Isachne veldcampii* K.G. Bhat & Nagendran		T	Aug.-Nov.	V.a, V.e, II.b	CR	Western Ghats
328.	Poaceae	*Ischaemum barbatum* Retz.		T	Aug.-Nov.	III.a, III.c		Asia
329.	Poaceae	*Ischaemum impressum* Hack.		T	Aug.-Nov.	V.a, II.b, VII		India
330.	Poaceae	**Ischaemum jayachandranii* R. Ansari, V.S. Ramach. & Sreek.		T	Aug.-Sept.	V.a, II.b, VII	CR	Western Ghats
331.	Poaceae	**Ischaemum cannanorensis* Sreek., V.J. Nair & N.C. Nair		T	Aug.-Nov.	V.a, II.b, VII		Western Ghats
332.	Poaceae	*Ischaemum copeanum* Sreek., V.J. Nair & N.C. Nair		T	Aug.-Nov.	V.a, II.b, VII		Western Ghats
333.	Poaceae	**Ischaemum elimalayanum* Sreek., V.J. Nair & N.C. Nair		T	Aug.-Nov.	V.a, II.b, VII		Western Ghats
334.	Poaceae	**Ischaemum malabaricum* Sreek., V.J. Nair & N.C. Nair		T	Aug.-Sept.	V.a, II.b, VII		Western Ghats
335.	Poaceae	*Ischaemum muticum* L.		T	Aug.-Oct.	V.a, II.b, VII		Philippines, New Guinea, Australia
336.	Poaceae	**Ischaemum pappinisseriense* Ravi, N. Mohanan & R. Rajesh		T	Aug.-Oct.	V.a, II.b, VII		Western Ghats
337.	Poaceae	**Ischaemum raui* Sreek., V.J. Nair & N.C. Nair		T	Aug.-Oct.	V.a, II.b, VII		Western Ghats
338.	Poaceae	**Ischaemum yadavii* Gad & Janarth.		T	Aug.-Oct.	V.a, II.b, VII		Western Ghats
339.	Poaceae	*Jansenella griffithiana* (Müll. Stuttg.) Bor		T	Aug.-Nov.	V.e, II. b		India and Sri Lanka
340.	Poaceae	**Jansenella neglecta* S.R. Yadav Shrirang Yadav, S.A. Chivalkar, K. V. C. Gosavi		T	Sept.-Dec.	V.a, II. b		Western Ghats

341.	Poaceae	*Microchloa indica* (L. f.) P. Beauv.		T	Aug.-Nov.	V.a, II		South America
342.	Poaceae	**Nanooravia kayyurense* Shaju , Rajendra prasad, Rijuraj & Ratheesh Narayanan		T	Aug.-Nov.	V.a		Western Ghats
343.	Poaceae	*Oplismenus compositus* (L.) P. Beauv.		T	Sept.-Oct.	V.a, II. b		Asia, Africa, Australia, South America, Mexico and Hawaii
344.	Poaceae	*Ophiuros bombaiensis* Bor. (Retz.) P. Beauv.		T	Sept.-Oct.	II.a		Peninsular India
345.	Poaceae	*Oryza rufipogon* Griff.		T	Sept.-Oct.	III.b, III.c		E and S India
346.	Poaceae	*Panicum antidotale* Retz.		T	Aug.-Nov.	V.a, V. e		India, Pakistan
347.	Poaceae	*Panicum brevifolium* L.		T	Sept.-Oct.	V.a, V. e		India
348.	Poaceae	*Panicum paludosum* Roxb.		T	Aug.-Dec.	V.a, V. e		India
349.	Poaceae	*Panicum repens* L.		T	Sept.-Oct.	V.a, V. e	LC	Wide spread
350.	Poaceae	*Paspalum canarae* (Steud.) Veldkamp		T	Aug.-Dec.	V.a, V. e	LC	Western Ghats
351.	Poaceae	*Paspalum canarae var. fimbriatum* (Bor) Veldkamp		T	Aug.-Dec.	V.a, V. e		Western Ghats
352.	Poaceae	*Paspalum scrobiculatum* L.		T	Sept.-Oct.	V.a, V. e		Australia and Sri Lanka
353.	Poaceae	*Pennisetum alopecuroides* (L.) Spreng.		T	Aug.-Nov.	V.a, IX. b		Asia and Australia
354.	Poaceae	*Pennisetum polystachion* (L.) Schult.		T	Sept.-Oct.	V.a, IX. b		Australia and Sri Lanka
355.	Poaceae	*Polytrias indica* (Houtt.) Veldkamp		T	Aug.-Sept.	V.a		Southern Taiwan
356.	Poaceae	*Setaria pumila* (Poir.) Roem. & Schult.		T	Sept.-Dec.	V.a, II. b		India
357.	Poaceae	*Sporobolus indicus* (L.) R.Br.		T	Aug.-Nov.	V.a, II. b		India
358.	Poaceae	**Spodiopogon rhizophorus* (Steud.) Pilg.		T	Aug.-Nov.	VI.a		Western Ghats
359.	Poaceae	*Themeda triandra* Forssk.		T	Aug.-Nov.	V.a, II. b		Africa, Australia, Asia
360.	Polygalaceae	*Polygala elongata* Klein ex Willd.		T	Jul.-Sept.	II.a		India
361.	Polygalaceae	*Salmonea cantoniensis* Vahl.		T	Jul.-Aug.	V.a, II. b		India and Malasia

362.	Pontederaceae	*Monochoria vaginalis* (Burm.f.) C. Presl	Kan: Nilothpala	T	Jul.-Sept.	IX.a	LC	Asia
363.	Rubiaceae	*Dentella repens (L.)* J.R. Forst. & G. Forst.		T	Apr.-Oct.	IX.b		Africa, Australia, Asia
364.	Rubiaceae	*Hedyotis cyanantha* Kurz.		T	Sept.-Nov.	V.b		India to Malesia
365.	Rubiaceae	*Hedyotis kurzii* Merr.		T	Sept.-Oct.	I.a, I.c, VI. a		India
366.	Rubiaceae	*Hedyotis griffithii* Hook.f.		T	Aug.-Sept.	V.a, V. b		Andaman-Nicobar, Srilanka
367.	Rubiaceae	*Hedyotis ovata* Thunb. ex Maxim.		T	Aug.-Sept.	V.a, V. b		China, India
368.	Rubiaceae	*Hedyotis pruinosa* Wight & Arn.		T	Sept.-Oct.	V.a, V. b		India, Vietnam
369.	Rubiaceae	*Houstonia caerulea* L.		T	Sept.-Oct.	V.a, V. b		Eastern Canada and the eastern United States
370.	Rubiaceae	*Mitracarpus hirtus* (L.) DC.	Kan: Nelanekkare	T	Sept.-Oct.	V.a, V. b		S. China to Tropical Asia
371.	Rubiaceae	**Neanotis foetida* (Dalzell) W.H. Lewis		T	Jul.-Aug.	II.a		Western Ghats
372.	Rubiaceae	**Neanotis tubulosa* (G. Don) Mabb.		CR	Jul.-Aug.	II.a, II. b		Western Ghats
373.	Rubiaceae	*Oldenlandia herbacea* (L.) Roxb.		T	Sept.-Nov.	IX.b		India
374.	Rubiaceae	*Spermacoce alata* Aubl.	Kan: Daarekaddi	T	Aug.-Nov.	VII		S. China to Tropical Asia
375.	Rubiaceae	*Spermacoce articularis* L.f.	Mal: Tartaval	T	Aug.-Nov.	VII		S. China to Tropical Asia
376.	Rubiaceae	*Spermacoce lasiocarpa* R.Br. ex Wall.		T	Sept.-Dec.	VII		India
377.	Rubiaceae	**Spermacoce malabarica* (Sivar. & Manilal) Sivar., R.V. Nair & Kunju		T	Aug.-Nov.	VII		Western Ghats
378.	Rubiaceae	*Spermacoce ocymoides* Burm.f.	Mal: Tharakeera; Kan: Nelanekkare	T	Jun.-Sept.	VII		Asia
379.	Rubiaceae	*Spermacoce pusilla* Wall.		T	Jun.-Sept.	VII		S. China to Tropical Asia
380.	Rubiaceae	*Spermacoce remota* Lam.		T	Jun.-Sept.	VII		S. China to Tropical Asia
381.	Rubiaceae	*Spermacoce verticillata* L.		T	Jun.-Sept.	VII		S. China to Tropical Asia
382.	Solanaceae	*Physalis angulata* L.		T	Jun.-Oct.	IX.b		Tropical & S. Africa to Central China and N. Australia

383.	Solanaceae	*Physalis minima* L.		T	Jun.-Oct.	IX.b		Tropical & S. Africa to Central China and N. Australia
384.	Urticaceae	*Laportea aestuans* (L.) Chew		T	Jun.-Oct.	V.b		Tropical Africa, Tropical Asia
385.	Urticaceae	*Pauzolzia zeylanica* (L.) Benn.		T	Jun. -Sept.	V.b		Tropical & S. Africa to Central China and N. Australia
386.	Violaceae	*Hybanthus enneaspermus* (L.) F. Muell.	Kan: Vishnukanti	T	Oct.-Feb.	I.a, II. a		India, Sri Lanka, Africa
387.	Xyridaceae	*Xyris indica* L.		T	Jun.-Sept.	V.e	LC	Guianas
388.	Xyridaceae	*Xyris pauciflora* Willd.		T	Jun.-Sept.	V.e		Asia
389.	Urticaceae	*Elatostema cuneatum* Wight		T	Jun.-Sept.	IX		India to Central Japan and Jawa
390.	Urticaceae	*Laportea interrupta* (L.) Chew.	Kan: Urusanige	T	Jun.-Oct.	X.b		World wide
391.	Zingiberaceae	**Curcuma oligantha* Trimen		CR	Oct.-Jan.	V.c		Western Ghats

Annexure II: Systematic composition (According to APG IV) of herbaceous plants of study region. (F: No of families; G: No of genera; TT: No. of total taxa; Et: No. of Endemic taxa)

Orders **(F/G/TT/ET)**	**Families** **(G/TT/ET)**	**Genera**	**Total taxa**	**Endemic taxa**
Nymphaeales (2/2/5/3)	Menynthaceae (1/4/2)	1)*Nymphoides* Seg.	4	2
	Hydetellaceae (1/1/1)	1)*Trithuria* Hook.f.	1	1
Alismatales (3/8/14/5)	Araceae (5/7/2)	1) *Amorphophallus* Blume ex Decne.	1	0

		2) *Ariopsis* Nimmo.	1	1
		3) *Arisaema* Mart.	3	1
		4) *Cryptocoryne* Fisch.ex Wydler	1	0
		5) *Remusatia* Schott.	1	0
	Alismataceae (1/1/1)	1) *Wiesneria* Micheli	1	1
	Hydrocharitaceae (2/6/2)	1)*Blyxa* Thouars ex Rich.	5	2
		1)*Ottelia* Pers.	1	0
Dioscoriales (1/1/1/0)	Burmanniaceae (1/1//0)	1)*Burmannia* L.	1	0
Liliales (1/2/3/1)	Colchiaceae (2/3/1)	1)*Gloriosa* L.	1	0
		2)*Iphiginia* Kunth.	2	1
Asparagales (3/9/10/2)	Orchidaceae (6/7/2)	1)*Acampe* Lindl.	1	0
		2)*Aerides* Lour.	1	1
		3) *Bulbophyllum* Thouars.	1	1
		4)*Crepedium* Blume.	1	0
		5)*Habenaria* Willd.	2	0
		6) *Liparis* Lindl.	1	0
	Hypoxidaceae (1/1/0)	1)*Curculigo* Gaertn.	1	0
	Amaryllidaceae (2/2/0)	1)*Crinum* L.	1	0
		2) *Pancratium* Dill ex L.	1	0
Commeninales (1/3/13/3)	Commelinaceae (3/13/3)	1)*Commelina* Plum ex.L.	5	0
		2)*Cyanotis* D. Don.	3	1

		3)*Murdannia* Royle.	5	2
Zingiberales (1/1/1/1)	Zingiberaceae (1/1/1)	1)*Curcuma* L.	1	1
Poales (4/42/125/50)	Xyridaceae (2/2/0)	1)*Xyris* Gronov ex.L.	2	0
	Eriocaulaceae (1/16/12)	1)*Eriocaulon* L.	16	12
	Cyperaceae (7/13/1)	1)*Cyperus* L.	2	0
		2)*Fimbristylis* Vahl.	3	0
		3)*Kyllinga* Rottb.	2	0
		4)*Rhynchospora* Vahl.	1	1
		5)*Pycreus* Rottb.	2	0
		6) *Schoenoplectiella* (Roxb.) Lye.	1	0
		7)*Scleria* P.J. Bergius	2	0
	Poaceae (37/94/36)	1)*Allopteris* Presl	1	0
		2)*Apluda* L.	1	1
		3)*Apocopis* Nees.	1	1
		4)*Artistida* L.	1	1
		5)*Arthraxon* P. Beavuv.	4	1
		6) *Arundinella* Raddi.	5	2
		7)Axonopus P. Beauv.	1	0
		8)*Bhidea* Bor	2	1
		9)*Brachiaria* (Sm.) Griseb	1	0
		10)*Chrysopogon* Trin.	1	1

		11)*Coelachne* R.Br.	3	1
		12)*Dichanthium* Willemet	3	3
		13)*Digitaria* L.	2	0
		14)*Dimeria* R.Br.	8	6
		15)*Echinochloa* P.Beauv.	1	0
		16)*Eleusine* Gaertn.	1	0
		17)*Eragrostis* Wolf	5	0
		18)*Garnotia* Brongn.	2	1
		19)*Glyphochloa* Clayton	5	1
		20)*Heteropogon* Pers.	3	0
		21)*Indopoa* Bor	1	0
		22)*Isachne* R.Br.	10	3
		23)*Ischaemum* L.	11	8
		24)*Jansenella* Bor	2	1
		25)*Microchloa* R.Br.	1	0
		26)*Nanooravia* Kiran Raj & Sivad.	1	1
		27)*Oplismenus* P.Beauv.	1	0
		28) *Ophiuros* Bor.	1	0
		29)*Oryza* L.	1	0
		30)*Panicum* L.	4	0
		31)*Paspalum* L.	3	2

		32)*Pennisetum* Rich.	2	0
		33)*Polytrias* Hack.	1	0
		34)*Setaria* L.	1	0
		35)*Sporobolus* R.Br.	1	0
		36)*Spodiopogon* Trin.	1	1
		37)*Themeda* Forssk.	1	0
Fabales (4/14/28/2)	Fabaceae (10/23/2)	1)*Aeschynomene* L.	2	0
		2)*Alysicarpus* Desv.	3	0
		3)*Crotalaria* L.	4	1
		4)*Derris* Lour.	1	0
		5)*Desmodium* Desv.	4	0
		6)*Indigofera* L.	3	0
		7)*Geissaspis* Wight & Arn.	2	1
		8)*Smithia* Aiton	2	0
		9)*Stylosanthes* SW.	1	0
		10)*Zornia* J.F. Gmel	1	0
	Ceasalpineaceae (1/2/0)	1)*Senna* Mill.	2	0
	Mimosaceae (1/1/0)	1) *Mimosa* L.	1	0
	Polygalaceae (2/2/0)	1)*Polygala* L.	1	0
		2)*Salmonea* Vahl.	1	0
Rosales (1/2/2/0)	Urticaceae (2/2/0)	1)*Laportea* L.	1	0

		2) *Pauzolzia* Gaudich.	1	0
Cucurbitales (1/2/2/1)	Begoniaceae (1/2/1)	1)*Begonia* L.	2	1
Oxalidales (1/2/2/0)	Oxalidaceae (2/2/0)	1)*Oxalis* L.	1	0
		2)*Biophytum* DC.	1	0
Malpigiales (3/5/12/2)	Euphorbiaceae (3/7/2)	1)*Acalypha* L.	2	0
		2)*Euphorbia* L.	4	2
		3)*Micrococca* Benth.	1	0
	Phyllanthaceae (1/4/0)	1)*Phyllantus* L.	4	0
	Violaceae (1/1/0)	2)*Hybanthus* Jacq.	1	0
Myrtales (3/5/13/8)	Lythraceae (2/10/7)	1)*Ammannia* L.	1	0
		2)*Rotala* L.	9	7
	Onagraceae (1/1/0)	1)*Ludwigia* L.	1	0
	Melastomataceae (2/2/1)	1)*Sonerila* Roxb.	1	0
		2)*Osbeckia* L.	1	1
Sapindales (1/1/1/0)	Meliaceae (1/1/0)	3)*Naregamia* Wight & Arn.	1	0
Malvales (1/5/7/0)	Malvaceae (5/7/0)	1)*Abutilon* Mill.	1	0
		2) *Melochia* L.	1	0
		3)*Sida* L.	3	0
		4)*Triumfetta* L.	1	0
		5)*Urena* L.	1	0
Brassicales (1/1/1/0)	Cleomaceae (1/1/0)	1)*Cleome* L.	1	0

Caryophyllales (5/12/18/0)	Amaranthaceae (6/10/0)	1) *Achyranthus* L.	2	0
		2)*Erva* L.	1	0
		3)*Alternanthera* Fossk.	2	0
		4)*Amaranthus* L.	2	0
		5)*Celosia* L.	2	0
		6)*Gomphreana* L.	1	0
	Droseraceae (1/2/0)	1)*Drosera* L.	2	0
	Caryophyllaceae (2/2/0)	1)*Polycarpaea* Lam.	1	0
		2)*Polycarpon* L.	1	0
	Nyctaginaceae (1/1/0)	1)*Boerhavia* L.	1	0
	Molluginaceae (2/3/0)	1)*Glinus* L.	2	0
		2)*Mollugo* L.	1	0
Ericales (1/1/5/1)	Balsaminaceae (1/5/1)	1)*Impatiense* L.	5	1
Gentianales (4/13/36/8)	Asclepiadaceae (1/2/2)	1) *Ceropegia* L.	2	2
	Rubiaceae (7/19/3)	1)*Dentella* J. R Forst & G. Forsst.	1	0
		2)*Hedyotis* L.	5	0
		3)*Houstonia* L.	1	0
		4)*Mitracarpus* Zucc.	1	0
		5)*Neanotis* W.H. Lewis	2	2
		6)*Oldenlandia* L.	1	0

		7)*Spermacoce* L.	8	1
	Gentianaceae (3/13/3)	1)*Canscora* Lam.	3	1
		2)*Canscorinlla* Shahina & Nampy.	2	2
		3)*Exacum* L.	6	0
		4)*Hoppea* Rchb.	2	0
	Loganiaceae (2/2/0)	*1)Mitrasacme* Labill.	1	0
		2)*Spigelia* L.	1	0
Boraginales (1/2/3/0)	Boraginaceae (2/3/0)	1)*Coldenia* L.	1	0
		2)*Heliotropium* L.	2	0
Solanales (2/4/4/0)	Convolvulaceae (1/2/0)	1)*Evovulus* L.	2	0
	Solanaceae (1/2/0)	1)*Physalis* L.	2	0
Lamiales (7/30/42/8)	Linderniaceae (1/3/0)	1)*Lindernia* Allioni.	3	0
	Pedaliaceae (2/2/0)	1)*Pedalium* L.	1	0
		2)*Sesamum* L.	1	0
	Acanthaceae (8/16/4)	1)*Asystasia* Blume.	2	0
		2)*Dicliptera* Juss.	1	0
		3)*Dipteracanthus* Poir.	1	0
		4)*Pseuderanthemum* Radlk. ex Lindau	1	0
		5)*Justicia* L.	4	1
		6)*Lepidagathis* Willd.	5	3
		7)*Rostelluria* Rchb.	1	0

		8)*Rungia* Nees.	1	0
	Lentibulariaceae (1/10/3)	1)*Utricularia* L.	10	3
	Lamiaceae (7/11/1)	1)*Anisochilus*. Briq.	2	0
		2)*Basilicum* Moench	1	0
		3)*Leucas* R.Br.	2	0
		4)*Pogostemon* Desf.	3	1
		5)*Hyptis* Jacq.	1	0
		6)*Ocimum* L.	1	0
		7)*Plectranthus* L. Hér.	1	0
	Orobanchaceae (6/10/2)	1)*Buchnera* Buch. -Ham.	1	0
		2)*Centrathera* R.Br.	1	0
		3)*Parasopubia* L.	2	2
		4)*Rhamphicarpa* Hochst. (Benth)	1	0
		5)*Sopubia* Buch-Ham.ex Don	1	0
		6)*Striga* Lour.	4	0
	Plantaginaceae (3/6/0)	1)*Dopatrium* Buch. -Ham. ex Benth.	2	0
		2)*Limnophila* R.Br.	1	0
		3)*Mecardonia* Ruiz & Pav.	1	0
		4)*Micocarpea* R.Br.	1	0
		5)*Scoparia* L.	1	0
Asterales (1/20/23/1)	Asteraceae (20/23/1)	1)*Acanthospermum* Schrank.	1	0

		2)*Adenoon* Dalzell.	1	1
		3)Acmella Rich. ex Pers.	1	0
		4)*Ageratina* Spach	1	0
		5)*Ageratum* L.	1	0
		6)*Artimisia* L.	1	0
		7) *Blumea* DC.	4	0
		8) *Bidens* L.	1	0
		9) *Calyptocarpus* Less.	1	0
		10) *Cyanthillium* Blume	1	0
		11)*Epaltes* (L.) Cass.	1	0
		12)*Eclipta*. L.	1	0
		13)*Elephantopus* L.	1	0
		14)*Emilia* Cass.	1	0
		15)*Grangea Adans*.	1	0
		16)*Sphagneticola* O. Hoffm.	1	0
		17)*Synedrella* Gaertn.	1	0
		18)*Tridax* L.	1	0
		19)*Tricholepis* DC.	1	0
		20)*Vernonia* DC.	1	0
Apiales (1/1/1/0)	Apiaceae (1/1/0)	1)*Centella* L.	1	0

Annexure III: Check list and other details of Trees, Shrubs and Climbers species from the study area (Climbers include twiners, creepers, stragglers etc.)

SL number	F	S-N	V-N	F-F	Phytogeographic distribution
1.	Acanthaceae	*Justicia adhatoda* L.	Kan: Aadusoge	Oct.Dec.	Indian subcontinent, Laos and Myanmar
2.	Anacardiaceae	*Mangifera indica* L.	Kan: Maavu	Feb.-Jun.	India
3.	Anacardiaceae	*Holigarna arnottiana* Hook.f.	Kan: Chere	Oct.-Feb.	Western Ghats
4.	Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Kan: Kuratiga; Mal: Kurayam	Oct.-Feb.	Sri Lanka to Southern China
5.	Annonaceae	*Uvaria narum* (Dunal) Blume	Kan: Kari maderi	Oct.-Mar.	Southern India and Sri Lanka
6.	Apocyanaceae	*Alstonia scholaris* (L.) R. Br.	Kan: Paale	Dec.-Mar.	Southern China, tropical Asia and Australasia
7.	Apocyanaceae	*Carissa carandas L.*	Kan: Karande	Apr-May.	India
8.	Apocyanaceae	*Gymnema sylvestre* (Retz.) Schult.	Mal: Madhunashini	Apr.-Oct.	Tropical Asia, China, the Arabian Peninsula, Africa, and Australia
9.	Apocyanaceae	*Kamettia caryophyllata* (Roxb.) Nicolson & C.R Suresh	Mal: Narumarathivu	Sept.-Jan.	Western Ghats
10.	Apocyanaceae	*Rauvolfia serpentina* (L.) Benth. ex Kurz	Kan: Garuda patala	Sept.-Nov.	India
11.	Apocyanaceae	*Tabernaemontana alternifolia* L.	Mal: Kuruttuppala	Apr-May.	India
12.	Apocyanaceae	*Ichnocarpus frutescens* (L.) W.T. Aiton	Mal: Paravalli	Oct.-Feb.	Tropical & Subtropical Asia to N. Australia
13.	Apocyanaceae	*Wrightia tinctoria* R.Br.	Mal: Bhanthappala	Mar.-Apr.	India, southeast Asia and Australia
14.	Apocyanaceae	*Holarrhena pubescens* Wall. ex G. Don	Kan: Haale	Oct.-Jan.	Central and southern Africa
15.	Areceae	*Scindapsus officinalis* (Roxb.) Schott.		Dec.-Mar.	South-central regions of China and the tropical parts of India
16.	Aristolochaceae	*Aristolochia indica* L	Kan: Eshwara balli	Nov.-Jan.	Indo-Malasia
17.	Asclepiadiaceae	*Calotropis gigantea* (L.) R.Br.	Kan: Ekka	Always	Tropical Asia, China, the Arabian Peninsula, Africa
18.	Asclepiadiaceae	*Dregea volubilis* (L.f.) Benth. ex Hook.f.	Mal: Vattakakkakodi	Aug.-Oct.	India
19.	Asclepiadiaceae	*Tylophora indica* (Burm. F.) Merr.	Kan: Antamoola	Jun.-Sept.	India
20.	Asclepiadaceae	*Hemidesmus indicus* (L.) r.Br.	Kan: Sogade beru,	Sept.-Jan.	Endemic to peninsular India

			Mal: Nannari		
21.	Asperagaceae	*Asperagus racemosus* Willd.	Kan: Shathavari	Aug.-Sept.	India
22.	Bignoniaceae	*Oroxylum indicium* (L.) Benth ex Kurz.	Eng: Indian trumpet flower	Dec.-Mar.	India
23.	Bomabacaceae	*Bombax ceiba* L.	Kan: Booruga	Dec.-Jan.	Asia
24.	Celastraceae	*Lophopetalum wightianum* Arn.	Tulu: Balpale	Dec.-Mar.	Asia
25.	Capparidaceae	*Capparis rheedei* DC.		Feb.-Jun.	Western Ghats
26.	Capparidaceae	*Capparis zeylanica* Wight.		Feb.-Jun.	Indo-China, China and Malesia, India
27.	Caesalpiniaceae	*Caesalpinia mimosoides* Lam.		Sept.-Oct.	China, India, Laos, Myanmar, Thailand, and Vietnam
28.	Caesalpineaceae	*Peltophorum pterocarpum* (DC.) K. Heyne	Eng: Copperpod tree	Sept.-Oct.	Southeastern Asia
29.	Combretaceae	*Terminalia paniculata* Roth	Kan: Maruva	Jan.-Mar.	South west India
30.	Caesalpineaceae	*Cassia fistula* L.	Mal: Konna	Oct.-Mar.	Indo-Malasia
31.	Caesalpiniaceae	*Caesalpinia mimosoides* Lam.		Jan.-Mar.	Indo-Malesia
32.	Caesalpineaceae	*Chamaecrista mimosoides* (L.) Greene	Mal: Theemullu	Jul.-Oct.	Tropical & S. Africa, Tropical Asia to N. Australia
33.	Ceasalpineaceae	*Senna occidentalis* (L.) Link	Kan: Kolthagache	Jul.-Aug.	Australia, southern and eastern USA and eastern Africa
34.	Caesalpineaceae	*Tamarindus indica* L.	Kan: Huli; Mal: puli	Apr.-Sept.	Native of Tropical Africa
35.	Clusiaceae	*Mammea suriga* (Buch. -Ham. ex Roxb.) Kosterm.	Kan: Suragi	Dec.-Mar.	Western Ghats
36.	Combretaceae	*Getonia floribunda* Roxb.	Kan: Injire	Jan.-Mar.	Western Ghats
37.	Combretaceae	*Terminalia catappa* L.	Kan: Kaadu badami	Jan.-Mar.	Asia, Africa, and Australia
38.	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Kan: Shanti	Jan.-Mar.	Southeast Asia
39.	Convolvulaceae	*Cuscuta chinensis* Lam.		Jan.-Mar.	China, India
40.	Convolvulaceae	*Argyreia boseana* Santapau & V. Patel		July-Dec.	Western Ghats
41.	Convolvulaceae	*Argyreia involucrata* Clarke.		Oct.-Feb.	India
42.	Convolvulaceae	*Argyreia nervosa* (Burm. f.) Bojer		Oct.-Feb.	India
43.	Convolvulaceae	*Erycibe oligantha* Merr. & Chun		Oct.-Feb.	Hainan, Vietnam
44.	Convolvulaceae	*Ipomoea cairica* (L.) Sweet	Kan: Bekkinahejje balli	Aug.-Oct.	Africa

45.	Convolvulaceae	*Ipomoea hederifolia* L.	Kan: Haaluballi	Oct.-Feb.	America
46.	Convolvulaceae	*Ipomoea mauritiana* Jacq.	Kan: Bujagumbala	Oct.-Feb.	West Africa
47.	Convolvulaceae	*Ipomoea obscura* (L.) Ker Gawl.	Mal: Thiruthali	Aug.-Oct.	Africa, Asia, and certain Pacific Islands
48.	Convolvulaceae	*Ipomoea pes-tigridis* L.	Mal: Pulicchuvadi	Oct.-Feb.	Asia, Africa, Australia
49.	Convolvulaceae	*Merremia tridentata* (L.) Hallier f.		Feb.-Jun.	tropical parts of the world
50.	Convolvulaceae	*Merremia umbellata* (L.) Hallier f.	Mal: Vayaara valli	Feb.-Jun.	Andaman and Nicobar
51.	Convolvulaceae	*Hewittia malabarica* (L.) Suresh	Mal: Ohanamvalli	Sept.-Nov.	tropical Africa, Asia and Polynesia
52.	Convolvulaceae	*Xenostegia filiformis* M.R. Almeida		Sept.-Nov.	Cape Prov.
53.	Cucurbitaceae	*Diplocyclos palmatus* (L.) C. Jeffrey	Kan: Shivalingi	Always	Tropical East Africa
54.	Cucurbitaceae	*Mukia maderaspatana* (L.) M. Roem.	Mal: Mukkalppeeram	Jul.-Oct.	Indomalaya and Meganesia
55.	Cucurbitaceae	*Solena amplexicaulis* Lam.			tropical southern Asia
56.	Dipterocarpaceae	*Hopea ponga* (Dennst.) Mabb	Kan: Doddelebogi	Oct.-Feb.	India
57.	Dioscoriaceae	*Dioscorea bulbifera* L.	Kan: Negiluhonne	Aug.-Oct.	Paleotropics
58.	Dioscoriaceae	*Dioscorea pentaphylla* L.	Kan: Kaadugumala	Aug.-Oct.	Indo-Malasia and China
59.	Dioscoriaceae	*Dioscorea wallichii* Hook	Mal: Kattukizhangu	Oct.-Dec.	India, Myanmar and Thailand
60.	Ebenaceae	*Diospyros candolleana* Wight	Kan: Kaare mara	Oct.-Mar.	Western Ghats of India and Sri Lanka.
61.	Elatinaceae	*Elatine ambigua* Wight.	Eng: Asian waterwort	Jul.-Sept.	California
62.	Euphorbiaceae	*Antidesma acidum* Retz.	Kan: Bilikoome	Jul.-Sept.	Asia
63.	Euphorbiaceae	*Breynia vitis-idaea* (Burm.f.) C.E.C. Fisch.	Mal: Pavalpulla	Mar.-May.	India
64.	Euphorbiaceae	*Bridelia retusa* (L.) A. Juss.	Kan: Kove mullu	Nov.-Mar.	Nepal, India, Sri Lanka,
65.	Euphorbiaceae	*Bridelia stipularis* (L.) Blume		Nov.-Mar.	Southeast Asia, southern China, and the Indian subcontinent.
66.	Euphorbiaceae	*Breynia Vitis-idaea* (Burm.) f.) C. Fischer	Mal: Pavalapulla	Mar.-May.	India
67.	Euphorbiaceae	*Falconeria insignis* Royle	Kan: Kannu potti	Aug.-Oct.	India, Nepal, Bangladesh, and Sri Lanka to Indochina
68.	Euphorbiaceae	*Flueggea virosa* (Roxb. ex Willd.) Royle	Mal: Vellappoolam	Mar.-May.	Tanzania
69.	Euphorbiaceae	*Jatropha curcas* L.	Kan: Jatropa	Oct.-Feb.	Mexico and Central America
70.	Euphorbiaceae	*Jatropha gossypiifolia* L.	Eng: Black Physinut	Oct.-Feb.	Native to Mexico, South America
71.	Euphorbiaceae	*Flueggea leucopyrus* Willd.	Kan: Sooli	Jul.-Dec.	India

72.	Euphorbiaceae	*Macaranga peltata* (Roxb.) Müll.Arg.	Kan: Uppaliga	Oct.-Feb.	India, Sri Lanka
73.	Euphorbiaceae	*Tragia hispida* Willd.	Kan: Uraisanige	Nov.-Dec.	India
74.	Euphorbiaceae	*Tragia involucrata* L.	Kan: Thurike soppu	Oct.-Jan.	India
75.	Fabaceae	*Adenanthera pavonia* L	Kan: Chenne	Mar.-Jun.	Brazil
76.	Fabaceae	*Erythrina variegata* L.	Kan: Mullu murukku	Jul.-Oct.	Eastern Africa
77.	Fabaceae	*Tephrosia purpurea* (L.) Pers.	Kan: Empali	Oct.-Jan.	India and Sri Lanka
78.	Fabaceae	*Mucuna pruriens* (L.) DC.	Kan: Naayisonagu; Mal: Naaykkuruna	Sept.- Oct.	Africa and tropical Asia
79.	Fabaceae	*Tadehagi triquetrum* (L.) H. Ohashi	Kan: Dodotte	Jul.-Sept.	Asia
80.	Fabaceae	*Vigna* sp		Mar.-Dec.	-
81.	Flacourtiaceae	*Flacourtia indica* (Burm.f.) Merr.	Kan: Jeide	Mar.-Sept.	Africa and tropical and temperate parts of Asia
82.	Flacourtiaceae	*Hydnocarpus pentandrus* (Buch. -Ham.) Oken	Kan: Chalmogr yenne mara	Oct.-Feb.	Western Ghats
83.	Hippocrataceae	*Reissantia indica* (Willd.) N. Hallé	Kan: Maderi	Sept.-Dec.	Tropical Asia.
84.	Hippocrataceae	*Reissantia sessiliflra* Navendu.	Kan: Maderi	Oct.-Mar.	Western Ghats
85.	Hippocrataceae	*Salacia fruticosa* Heyne ex Lawson.	Kan: Ekanayakana beru	Dec.-Mar.	Western Ghats
86.	Lamiaceae	*Tectona grandis* L.f.	Kan: Tega	Jun.-Aug.	Bangladesh, India, Indonesia
87.	Leeaceae	*Leea indica* (Burm. f.) Merr.		Oct.-Feb.	Indo Malasia and China
88.	Leycithidaceae	*Careya arborea* Roxb.	Kan: Daddala	Feb.-Apr.	Indian Subcontinent, Afghanistan, and Indochina
89.	Lauraceae	*Cassytha filiformis* L.	Kan: Aakasha balli	Aug.-Dec.	Americas, Indomalaya, Australasia, Polynesia
90.	Lauraceae	*Litsea glutinosa* (Lour.) C.B. Rob.	Mal: Elumburukki	Oct.-Feb.	Indo-Malesia and China
91.	Lauraceae	*Alseodaphne semecarpifolia* Nees.	Kan: Kulirmaavu	Mar.-May.	Western Ghats and Sri Lanka
92.	Loganiaceae	*Strychnos nux-vomica* L.	Kan: Kasaraka	Jan.-Feb.	India and to southeast Asia
93.	Loranthaceae	*Dendrophthoe falcata* (L.f.) Ettingsh.	Kan: Bandanike	Nov.-Mar.	India

94.	Loranthaceae	*Heicanthes elasticus* (Desr.) Danser.		Dec.-Mar.	Southern Western Ghats
95.	Loranthaceae	*Helixanthera intermedia* (Wight) Danser.		Feb.-Jun.	Southern Western Ghats
96.	Malvaceae	*Hibiscus surattensis* L.	Kan: Mullu gogu	Sept.-Nov.	Africa
97.	Melastomataceae	*Melastoma malabathricum* L.	Kan: Nekkarika	Feb.-Jun.	Southeast Asian region
98.	Melastomataceae	*Memecylon edule* Roxb.	Kan: Nemaaru	Jan.-Mar.	Western Ghats
99.	Melastomataceae	*Memecylon malabaricum* Cogn.	Kan: Ollekodi	Feb.-Jun.	Western Ghats
100.	Melastomataceae	*Memecylon randerianum* S.M. Almeida & M.R. Almeida		Feb.-Jun.	India
101.	Melastomataceae	*Memecylon umbellatum* Burm. f.	Kan: Harchari	Feb.-Jun.	India, the Andaman Islands
102.	Meliaceae	*Aglaia elaeagnoidea* (a. Juss.) Benth.		Feb.-Mar.	Indo-Malesia to Pacific Islands
103.	Menispermaceae	*Coscinium fenestratum* (Goetgh.) Colebr.		May. -Oct.	South Asia
104.	Mensispermaceae	*Cyclea peltata* (Lam.) Hook.f. and Thomas	Kan: Haade	All season	India and Sri Lanka
105.	Menispermaceae	*Diploclisia glaucescens* (Blume) Diels	Mal: Vaatamkolli	Feb.-Mar.	South Asia
106.	Menispermaceae	*Cocculus hirsutus* (L.) Diels	Kan: Daagadi soppu	Feb.-Mar.	India
107.	Mimosaceae	*Acacia caesia* (L.) Willd.	Kan: Kaadu seege	Jan.-May.	Indo-Malasia
108.	Mimosaceae	*Acacia pennata* (L.) Willd.		Jun.-Aug.	South and Southeast Asia
109.	Mimosaceae	*Acacia mangium* Willd.	Kan: Manjium	Jun.-Oct.	Western Province of Papua New Guinea
110.	Mimosaceae	*Dichrostachys cinerea (*L.) Wight & Arn.	Kan: Seege	Sept.-Dec.	Africa
111.	Mimosaceae	*Albizia odoratissima* (L.f.) Benth.	Kan: Bilvaara	Mar.-May.	Indo-China
112.	Moraceae	*Ficus arnottiana* (Miq.) Miq.	Kan: Goli mara	Dec.-Sept.	India
113.	Moraceae	*Ficus benghalensis* L.	Kan: Aaladamara	Dec.-Jun.	India
114.	Moraceae	*Ficus callosa* Willd.	Kan: Neeruaate	Apr.-Jul.	India, southern China, Indo-China
115.	Moraceae	*Ficus exasperata* Vahl.	Kan: Paaje	Dec.-Jun.	tropical Africa and southern Asia
116.	Moraceae	*Ficus heterophylla* L.f.	Mal: Vallitherakam	Apr.-Jun.	China
117.	Moraceae	*Ficus racemosa* L.	Kan: Atti	Always	Australia and tropical Asia
118.	Moraceae	*Ficus religiosa* L	Kan: Ashwatha	Mar.-Jul.	Indochina
119.	Moraceae	*Ficus tinctoria* G. Forst.		Jan.-Mar.	Oceania and Indonesia
120.	Myrtaceae	*Syzygium caryophyllatum* (L.) Alston	Kan: Kuntala	Feb.-May.	Sri Lanka and south India
121.	Moraceae	*Ficus arnottiana* (Miq.) Miq.	Kan: Goli mara	Dec.-Sept.	India
122.	Myrtaceae	*Syzygium cumini* (L.) Skeels		Mar.-May.	India

123.	Opiliaceae	*Cansjera rheedii* Blanco	Kan: Karadi soppu	Jan.-Apr.	India, China
124.	Oleaceae	*Jasminum malabaricum* Wight	Kan: Kaadu mallige	Oct.-Feb.	India, and Sri Lanka
125.	Oleaceae	*Olea dioica* Roxb.	Kan: Bilisarali	Feb.-Apr.	India
126.	Papilionaceae	*Pongamia pinnata* (L.) Pierre	Kan: Honge mara	Jan.-Apr.	Tropical Asia, Australia and Pacific islands
127.	Ranunculaceae	*Naravelia zeylanica* (L.) DC.	Mal: Vathakkodivalli	Aug.-Oct.	Asia
128.	Rhamnaceae	*Ventilago madraspatana* Gaertn.	Mal: Vempata	Oct. -Dec.	India
129.	Rhamnaceae	*Ziziphus jujuba* Mill.	Mal: Lanthapazam	Mar.-May.	World wide
130.	Rhamnaceae	*Ziziphus oenopolia* (L.) Mill.	Kan: Choori mullu	Oct. -Nov.	South-East Asia
131.	Rhamnaceae	*Ziziphus rugosa* Lam.	Kan: Kotte mullu, Belmr hannu	Feb.-Mar.	Western Ghats
132.	Rubiaceae	*Benkara malabarica* (Lam.) Tirveng.	Mal: Cholakara	Mar.-Jun.	Western Ghats, Sri Lanka
133.	Rubiaceae	*Canthium coromandelicum* (Burm.f.) Alston.	Kan: Kaare gida	Apr.-May.	India, Sri Lanka and East Africa
134.	Rubiaceae	*Morinda citrifolia* L.	Kan: Noni	Sept.-Oct.	Southeast Asia
135.	Rubiaceae	*Mussaenda bammleri* Valeton	Kan: Bellante	Set. -Nov.	African and Asian tropics and subtropics
136.	Rubiaceae	*Ixora brachiata* Roxb.	Kan: Kurejji	Dec.-Apr.	Western Ghats
137.	Rubiaceae	*Ixora coccinea* L.	Kan: Kepula	All season	Southern India, Bangladesh, and Sri Lanka
138.	Rubiaceae	*Ixora malabarica* (Dennst.) Mabb.		Oct.-Dec.	Western Ghats
139.	Rubiaceae	*Psychotria intrudens* Miq.		May. -Aug.	Jawa
140.	Rutaceae	*Atalantia wightii* Yu. Tanaka	Kan: Kaadu nimbe	Jun.-Oct.	Western Ghats
141.	Rutaceae	*Glycosmis pentaphylla* (Retz.) DC.	Mal: Kuttippannel	Sept.-Nov.	Southeast Asia and northern Australia
142.	Rutaceae	*Zanthoxylum rhetsa* (Roxb.) DC.	Kan: Kaavate	Jun.-Jul.	Philippines and south to northern Australia
143.	Santalaceae	*Santalum album* L.	Kan: Shree gandha	Mar.-Aug.	Peninsular India, Eastern Indonesia and northern Australia
144.	Sapindaceae	*Allophylus cobbe* (L.) Raeusch.	Moovila	Mar.-Aug.	South Africa, South America
145.	Sapotaceae	*Mimusops elengi* L.	Kan: Renje	Feb.-Jun.	Asia and Australia
146.	Smilacaceae	*Smilax zeylanica* L.		Sept.-Nov.	India and Malasia
147.	Solanaceae	*Datura stramanium* L.	Kan: Dattura	Jun.-Oct.	Tropical & S. Africa to Central China and N.

					Australia
148.	Sterculiaceae	*Helicteres isora* L.	Kan: Yedamuri	Aug.-Jan.	Southern Asia and northern Oceania
149.	Tiliaceae	*Grewia nervosa* (Lour.) Panigrahi	Mal: Kottakka	Feb.-Apr.	Western Ghats
150.	Ulmaceae	*Holoptelea integrifolia* Planch.	Kan: Thapasee mara; Mal: Aaval	Sept.-Jan.	India-China and Myanmar
151.	Ulmaceae	*Trema orientalis* (L.) Blume		Aug.-Nov.	South Africa, southern China
152.	Verbinaceae	*Lantana camara* L.	Kan: Kaadugulabi	Oct.-Feb.	Mexico, Central America
153.	Verbinaceae	*Rotheca serrata* (L.) Steane &Mabb.		Oct.-Feb.	India, Sri Lanka and Malaysia
154.	Verbenaceae	*Stachytarpheta indica* (L.) Vahl	Kan: Kaadu uttarane	Aug.-Nov	Caribbean
155.	Verbinaceae	*Stachytarpheta jamaicensis* (L.) Vahl.		Jun.-Dec.	Southern Asia and northern Oceania
156.	Violaceae	*Hugonia mystax* Cav.		Oct.-Feb.	peninsular India and Sri Lanka
157.	Vitaceae	*Ampelocissus latifolia* (Roxb.) Planch.	Kan: Kaake hannu	Jun.-Sept.	Bangladesh, India, Nepal, Pakistan
158.	Vitaceae	*Cayratia pedata* (Lam.) Gagnep.	Kan: Sanna kandadi beelu	Aug.-Feb.	India, Indonesia
159.	Vitaceae	*Cayratia trifolia* (L.) Domin	Kan: Kaama pattige balli	May. -Oct.	Australia and Asia
160.	Vitaceae	*Cissus elongata* Roxb.		May. -Nov.	India to Hainan and Malaya
161.	Vitaceae	*Cyphostemma ternatum* (Forssk.) Desc.		Jun.-Nov.	Northeast Africa to southern Arabia

Annexure IV: Details of ethnobotanically significant plants in the study region.

	Family	Scientific name	Vernacular name	Used for/property	Parts used	Study region
1.	Acanthaceae	*Asystasia gangetica* (L.) Anders.	Tulu: Maithal	Body swellings (not applicable for injuries), Antifungal	Leaf, stem	Bandadka
2.	Acanthaceae	*Lepidagathis prostrata* Dalz.	Kan: Paare mullu	Liver problems	Whole plant	Muligadde
3.	Amaranthaceae	*Aerva lanata* (L.) Juss.ex. Schult.	Mal: Cherula	Kidney stone	Whole plant	Kotappara
4.	Anacardiaceae	*Holigarna ferruginea* Hook.f.	Mal: Kattuchere Eng: Black varnish tree of Malabar	For intestinal worms (dogs), culinary	Bark, Tender leaves	Bandadka
5.	Anacardiaceae	*Buchanania lanzan* Spreng.	Mal: Erachi kooti, Erpe	Bone fracture (All type of animals)	Leaves	Bandadka
6.	Anacardiaceae	*Mangifera indica* Linn.	Mai: Kaattu mavu, Eng: Wild Mango	Dysentery in cows	Bark	Kotappara
7.	Annonaceae	*Uvaria narum* (Dunal) Blume		Intestinal worms	Root	Adka
8.	Apocyancaeae	*Holarrhena pubescence* (Buch. - Ham) Wall.ex G. Don	Kan: Kodagasana	Dysentery	Flower	Konaje
9.	Areceae	*Ariopsis peltata* Nimmo.		Culinary	Tender leaf	Maniyampara
10.	Areceae	*Scindapsus officinalis* (Roxb.) Schott.	Mal: Kuliande adi	For blood circulation, to purify the air in room or hut	Twig	Kotappara
11.	Asclepiadiaceae	*Calotropis gigantea* (L.) R.Br.	Kan: Ekka	Skin allergy	Latex	Konaje
12.	Aristolochaceae	*Aristolochia indica* L.	Mal: Urdooki Kan: Eeshwara balli	Fever, Loss of appetite, Poisonous bites (cows and human)	Whole plant or root	Koila, Kasaragod
13.	Asperagaceae	*Asperagus racemosus* Willd.	Mal & Kan: Shatavari	Delivered woman for lactation	Storage roots	Madayipara, Mukka-surathkal
14.	Asteraceae	*Blumea oxydonta* DC.	Tulu: Kattumulangi	Intestinal worms	Whole plant	Madayipara

15.	Asteraceae	*Elephantopus scaber* Linn.	Mal: Anayaadi Eng: Prickly leaved elephants' foot	To enhance milk production in cows, Stomach ulcer	Whole plant	Kasaragod
16.	Cleomaceae	*Cleome viscosa* L.	Mal: Kattu Kan: kadugu	Ear sores.	Whole plant	Kasaragod
17.	Caesalpiniaceae	*Caesalpinia mimosoides* Lam.	Kan: Chende mullu	Food	Flowers and Tender leaves	Konaje
18.	Celastraceae	*Lophopetalum wightianum* Arn.	Thulu: Nerolu	Diarrhea (cows)	Bark	Koila
19.	Combretaceae	*Getonia floribunda* Roxb.	Kan: Enjire	Tender leaf juice given for dysentery in infants	Tender leaf	Koila
20.	Combretaceae	*Terminalia bellirica* (Gaertn) Roxb.	Mal: Thani, Anile	Burn, head ache due to cold fever	Bark, seeds	Maniyampara
21.	Covolvulaceae	*Cuscuta chinensis* Lam.	Kan: Seethe balli	Hair conditioner, coolant during summer hot	Whole plant	Konaje
22.	Convolvulaceae	*Merremia umbellata* (L.) Hull.	Kan: Kulavina balli	To reduce burning sensations	Whole plant	Perla
23.	Cluciaceae	*Garcinia indica* (Thouars) Choisy	Kan: Punarpuli	Beverage, Culinary, to treat burns	Leaf, fruit and seeds	Maniyampara
24.	Cluciaceae	*Mammea suriga* (Buch. -Ham.ex Roxb.) Kosterm.	Kan: Suragi	Scent, Garland	Flowers	Maniyampara
25.	Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers	Kan: Bappute	Kidney stone, Stomach bloating due to gastritis	Leaf	Konaje
26.	Droseraceae	*Drosera indica* L.	Kan: Huluhidka	Whooping cough	Whole plant	Madayipara
27.	Eriocaulaceae	*Eriocaulon eurypeplon* Koern.	Kan: Maple toppi	Hand pimple	Whole plant	Kotappara
28.	Euphorbiaceae	*Bridelia scandens* (Roxb.) Willd.	Kan: Bandanaaru	Blood purifier	Bark	Maniyampara
29.	Euphorbiaceae	*Breynia vitis –idaea* (Burm.f.) C. Fischer	Kan: Sarali	Menstrual pain	Tender leaves	Konaje
30.	Euphorbiaceae	*Euphorbia hirta* L.	Mal: Kulinagappalam	Nail infection (Paronychia)	Latex	Madayipara
31.	Euphorbiaceae	*Securinega leucopyrus* (Willd.) *Muell.*	Kan: Koorambila	Cold	Leaves	Maniyampara
32.	Fabaceae	*Cassia alata Linn.* (*C. herpetica* Jacq)	Mal: Aanattagara Eng: Ring worm shrub	Skin allergy (both human and cows)	Leaves	Maniyampara

33.	Fabaceae	*Senna tora* (L.) Roxb.	Kan: Thajanku	Culinary	Tender leaves	Konaje
34.	Fabaceae	*Mucuna pruriense* (L.) DC.	Naayi sonangu, Naaykuruna	Beverage	Seeds	Konaje
35.	Fabaceae	*Zornia gibbosa* Span.	Kan: Maddina ele.	Fresh injury or cuts	Leaves	Konaje
36.	Hypoxidaceae	*Curculigo orchiodes* Gaertn.	Mal: Nelappana	Heavy white discharge, kidney stone.	Storage roots	Madayipara
37.	Lamiaceae	*Leaucas linifolia* (Roth) Spreng.	Kan: Thumbe	Mumps, cough, fever	Whole plant	Madayipara
38.	Lamiaceae	*Pogostemon quadrifolius* (Benth.) F. Muell.		To protect skin from insects (Cows)	Twigs	Maniympara
39.	Lauraceae	*Litsea glutinosa* (Lour.) C.B. Robinson.	Mal: Ellu kooti	Bone fracture (All type of animals)	Leaves	Madayipara
40.	Loganiaceae	*Strichnos wallichiana* Linn.	Mal: Chittar valli	To relieve from joint pains due to Arthritis.	Bark	Madayipara
41.	Lentibulariaceae	*Utricularia reticulata* Smith.	Mal: Kaaka poo	Urinary tract infections	Whole plant	Madayipara
42.	Lecithidaceae	*Careya arborea* Roxb.	Mal: Pezhu, Kan: Daddala	Throat irritation, menstrual pain, Diarrhea	Bark	Madayipara
43.	Leeaceae	*Leea indica* (Burm.f.) Merr.	Mal: Nedthe	For bone pricks	Leaves	Konaje
44.	Malvaceae	*Hibiscus hisidissimus* Griffith.	Tul: Kairpuli	Back pain	Bark	Kumbla
45.	Malvaceae	*Hibiscus surattensis* L.	Kan: Puli gogu	Culinary	Leaves and flowers	Maniyampara
46.	Melastomataceae	*Melastoma malabathricum* Linn.	Kan: Dodda nekkare	To avoid premature embryo abortion (Cows), culinary	Leaves	Kommangala
47.	Melastotaceae	*Memycelon malabaricum* (Clarke) Cogn.	Kan: Ollekudi	Herpes	Leaves	Mujungavu
48.	Meliaceae	*Naregamia alata* Wight and Arn.	Mal: Neelanarakam	Head ache, Fever (Cows)	Whole plant	Mujungavu
49.	Menispermaceae	*Diploclisia glucascense* (Blume) Diels.	Mal: Udira valli	To relieve from joint pains due to Arthritis.	Bark	Kumbla

50.	Menispermaceae	*Cyclea peltata* (Lam.) Hook and Thoms.	Mal: Padathali	Hair growth and eye cooler, Intestinal worms, poisonous bites	Leaves, Roots or whole plant	Kommangala
51.	Mimosaceae	*Mimosa pudica* L.	Mal: Lajjalu	Mouth ulcer	Roots	Mujungavu
52.	Moraceae	*Ficus exasperata* Vahl.	Kan: Paajale	To clean vessels	Leaves	Mujungavu
53.	Moraceae	*Artopcarpus hirsutus* Lam.	Mal: Plav, Kan: Halasu	Broken horns (cows)	Latex	Bandadka
54.	Moraceae	*Ficus hispida* Linn.f.	Mal: Eruma nakku	After delivery to induce easy placenta expel (cows) Onychosis.	Twigs Latex	Mujungavu, Madayipara
55.	Moraceae	*Ficus racemosa* L.	Kan: Atti	Multipurpose	Leaves, bark and fruits	Konaje
56.	Moraceae	*Strebulus asper* Lour.	Tul: Ponnalige	Menstrual pain	Leaves	Konaje
57.	Myrtaceae	*Syzigium caryophyllatum* (L.) Alston	Kan: Kuntala	Culinary	Tender leaves, fruits	Konaje
58.	Nyctaginaceae	*Boerhaavia diffusa* L.	Kan: Thagilame, Mal: Thazudama	Mumps (To reduce pain), To rejuvenate blood	Leaves and roots	Kommangala
59.	Oleaceae	*Jasminum malabaricum* Wight.	Mal: Kaatumulla	Body swellings.	Leaves	Konaje
60.	Phyllanthaceae	*Phyllanthus emblicua* (L.)	Kan: Nelli kai, Mal: Nellikka	Multipurpose	Leaves and fruits	Kommangala
61.	Piperaceae	*Peperomia pellucida* (L.) Kunth	Kan: Neeru kaddi	Culinary	Leaves and stem	Kommangala
62.	Rhamnaceae	*Ventilago madraspatana* Gaertn.	Kan: Kempu beru, Aithala beelu, Tul: Maithal	To prepare medicated oil	Root	Konaje
63.	Rhamnaceae	*Zizipus oenoplia* Mill.	Kan: Choori mullu	Removal of prickly minute thorns from eye, to treat pimple, For hip muscular contraction, poisonous insect bites	Tender leaves	Konaje
64.	Rhamnaceae	*Zizipus rugosa* Lam.	Kan: Kotte, Belmar hannu	Hair conditioner	Leaves	Konaje
65.	Rubiaceae	*Catunaregum spinosa* (Thumb.) Tirveng.	Mal: Malankaara, Kan: Kaare kai gida	Ear boring, Dysentery	Spines and fruits	Komman gala

66.	Rubiaceae	*Ixora brachiata* Roxb.	Kan: Gorajji	Culinary	Tender leaves	Konaje
67.	Rubiaceae	*Ixora coccinea* L.	Mal: Chethi, Mal: Kepula	Skin allergies, pregnancy care	Tender leaves, Roots, flowers, fruits	Konaje
68.	Rubiaceae	*Hedythodis auricularia* L.	Kan: Nela nekkarika	Indigestion	Leaves	Komman gala
69.	Rubiaceae	*Spermacoce ocymoides* Burm.f.	Kan: Nelanekkarika	Culinary	Leaves	Konaje
70.	Rutaceae	*Glycosmis pentaphylla* (Retz.) A. DC.	Mal: Kuttippanalu	Body swellings (cows)	Leaves	Kotappara
71.	Sapotaceae	*Mimusops elenji* L.	Kan: Renje	Garland	Flowers	Mujungavu
72.	Sapindaceae	*Allophylus cobbe* (L.) Raeush.	*Mal:* Moovila, Kan: Moorele, Pachche maddu	udder mastitis (cows)	Leaves	Madayipara
73.	Tiliaceae	*Grewia serrulata* DC.	Tul: Kapadanji	Menstrual pain	Bark	Kumbla
74.	Tiliaceae	*Grewia microcos* L.		To maintain proper ovulation in cows	Bark	Mujungavu
75.	Tiliaceae	*Helicteres isora* L.	Mal: Kaivun	Hair oil	Fruits	Maniyampara
76.	Verbinaceae	*Callycarpa tomentosa* (L.) Murr.	Mal: Cheru theku	Collection of honey	Leaves, flowers	Bandadka
77.	Violaceae	*Hybanthus enneaspermus* (L.) F. Muell.	Kan: Vishnu kanthi	Coolent	Whole plant	Muligadde
78.	Xyridaceae	*Xyris indica* L.		Skin allegy	Whole plant	Mujungavu

LIST OF PUBLICATIONS AND PRESENTATIONS

LIST OF PUBLICATIONS

- Rashmi, K. and Krishnakumar, G.2013. *Eriocaulon gopalakrishnanum* sp. nov. (Eriocaulaceae) from the Western Ghats, India. *Nordic Journal of Botany*., 30: 001–004.

- Rashmi, K. and Krishnakumar, G. 2015. *Hedyotis kurzii* (Rubiaceae): A new record for Peninsular India. *Rheedea.*, Vol. 25(2) 146-147.

- Rashmi, K. and Krishnakumar, G. Donald, H. Les. 2017. *Blyxa mangalensis*, a new species of Hydrocharitaceae from India. *Kew Bulletin*.,72.

- Rashmi, K. and Krishnakumar, G. 2020. *Eriocaulon lanceolatum* var. *bhatkalense* var. Nov. (Eriocaulaceae)- A New Variety from The Western Ghats, Indi. *Int J Plant Anim Environ Sci*., 10 (3): 135-139.

LIST OF PRESENTATIONS

- "RET plant diversity on the grassland foot hills of southern coastal area, Western Ghats". *XXVIII Annual Conference of Indian Association for Angiosperm Taxonomy & International Symposium on Conservation of Angiosperm Diversity*: October 29-31, 2018. The Maharaja Sayajirao University of Baroda, Vadodara 390002. Gujarat, India.

- Presented a paper entitled "Thaggu pradeshada hullugavalina malegalada sasyaprabhedagalalli iruva paragasparshada vaividhyathegalu".*16TH Kannada Vijnana Sammelana.* Karanataka Science Congress.September 17, 2021.Mangalore University. Mangalagangothri, Mangaluru.

PLATES

Plate 1: A view from plateau top of Valachil.

Plate 2 :**Study location**: Neerumarga Plateau

Plate 3: Bhatkal plateau during heavy monsoon phase

Plate 4. Study location: Posadi gumpe laterite hillock

Plate 5: Study Location: Koila plateau

A & B.Grassy hill slopes

Plate 6: Study location: Maniyampara Plateau

A & B. Plateau during initial phase of monsoon

Plate 7. Study location: Maniyampara plateau
A. The Plateau during heavy monsoon phase, B.Temporary water pool after a heavy shower

Plate 8: Study location: Madayipara Plateau

A&B. Soil filled areas showing *Eriocaulon's*, sedges and grasses, C. *Oryza rufipogon in edges of* water pool

Plate 9. Quadrat Studies

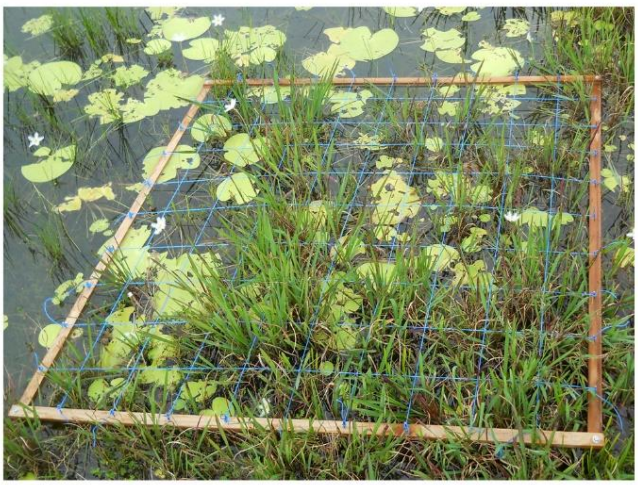

Plate:10: Study Location: Bhatkal plateau

A. *Eriocaulon lanceolatum* var.*bhatkalense,*B.*Eriocaulon cuspidatum* in small temporary pool(width up to 200 cm), C.*Lepdigathis prostrata* in vegetative growth on exposed rock surface,D.Soil filled areas, E.*Utricularia reticulata* & *Eriocaulon lanceolatum* var.*bhatkalense* in EFV, F. *Blyxa aubertii* in drainage channel

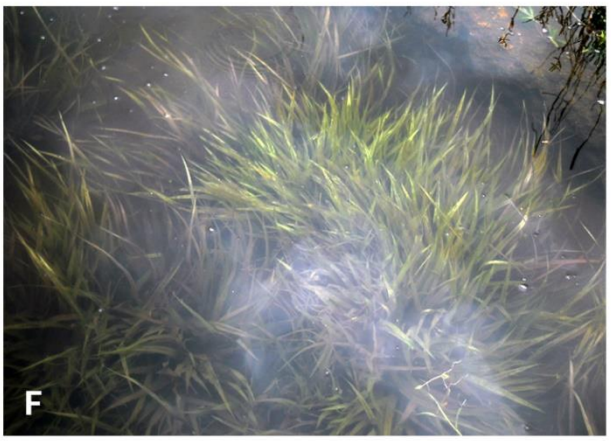

Plate: 11.: Study Location : Bhatkal Plateau
A.Soil filled depressions. B.Field work, C. Vegetation in heavy monsoon, D. Plateau in a cloudy day, E.*Eriocaulon*'s in flower and vegetative growth of Poaceae members, F.Lateritic rocky hill slopes with vegetation on rock crevices.

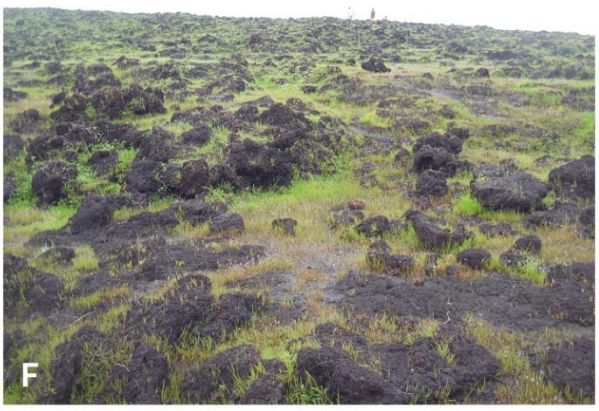

Plate: 12: Study Location : Valachil

A.Hill slope with large rock Boulders.,B.*Rauvolfia serpentina*, C.*Eriocaulon lanceolatum* var.*lanceolatum*,D.*Ariopsis peltata*,F.*Asparagus racemosus*, *G.Utricularia striatula*

Plate 13: Study location: Neerumarga

A-B.Temporary ponds & rock crevices showing vegetation,
C.*Utricularia lazulina* in soil filled areas,D.Grassy slope and soil filled area.
E.Soil filled areas in rock edges showing vegetation,
F.*Hedyotis cyanantha*

Plate 14: Study location:Konaje,Mudipu and Valachil Plateau

A: Slow flowing stream, B.Edges of stream,
C & D.Rock crevices and channel like areas,
E.*Lindernia ciliata* in Ephemeral flush vegetation,
F.*Eriocaulon eurypeplon* in soil filled area.

Plate 15. Study location: Maniyampara
A.Temporary stream B.*Eriocaulon eurypeplon* in edges of stream. C.*Eriocaulon richardianum* in EFV, D.*Blyxa octandra* in water pool

Plate 16. Study location: Bhatkal plateau

A. *Centranthera indica* , B.*Utricularia graminifolia*,
C. *Justicia procumbens*, D.*Eriocaulon stellulatum*,
E. *Eriocaulon xeranthemum*, F.*Eriocaulon heterolepis*

Plate 17: Study Location : Konaje
A-D. Temporary water pool and its edges showing different species, C&E. *Crotalaria quinquifolia*

Plate 18: Study location: Mudipu, Madayipara
A.*Nymphoides indica* & *Ischaemum barbatum*, in deep water pool B-F. *Rotala rotundifolia*, *Ischaemum barbatum*, *Rotala malampuzhensis, Eriocaulon cuspidatum,Schoenplectiella articulata* and *Blyxa octandra* in the egdes of pond.

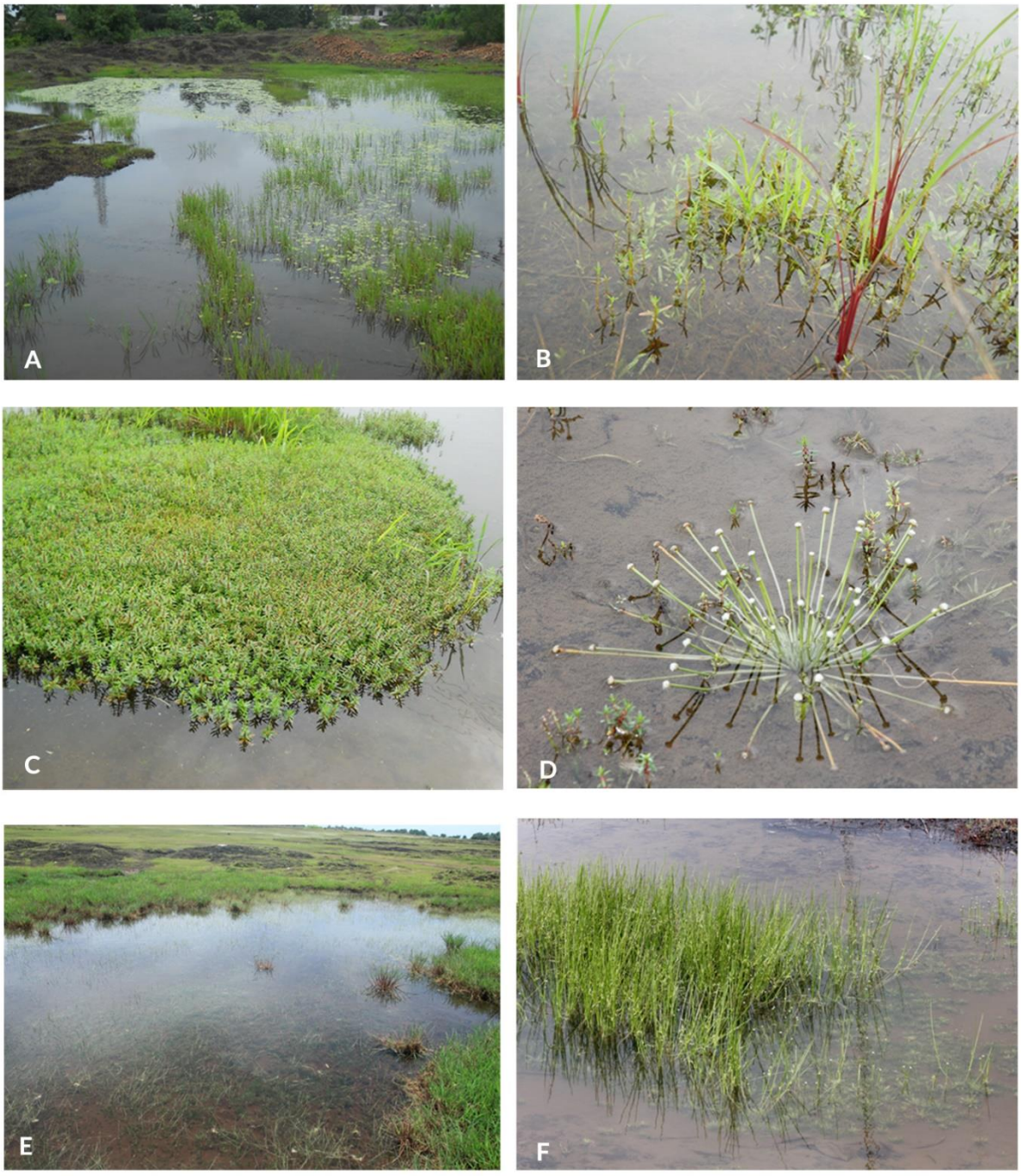

Plate 19: Study Location: Kommangala, Maniyampare, Bandaduka
A & B. Ephemeral rock pool,C.Rock Boulders under covered by trees, D.Rock crevices

Plate 20: Study Location: Kotappara & Konaje

A & B . *Eriocaulon gopalakrishnanum,*(C-F).*Blyxa mangalensis*

Plate 21: Study Location: Bhatkal, Mudipu & Konaje

A.*Striga gesneroids* as root parasite ,B.*Liparis rheedii* in shady region, C.*Canscorinella stricta* on rock crevices of RB,D.*Utricularia reticulata* associated with *Eragrostis indica*,E.*Utricularia lazulina* & *Eriocaulon eurypeplon* on rock crevices,F.*Impatiens oppositifolia* on stream

Plate 22. Study Location: Hosangady

A.Temporary water pool,B.*Blyxa echinosperma*, C.*Schoenplectiella articulata* D.*Rotala kasaragodensis* in water pool during post monsoon phase.

PLATE 23: STUDY LOCATION: SEETANGOLI & KOMMANGALA

A & B: Marshy areas showing *Lindernia hyssopoides* and *Epaltes divaricata*,
C & D: *Anisochilous carnosus* and *Begonia malabarica* near shady regions of rocks
E-F: *Eriocaulon cinerum*

Plate 24: Study Location: Koila, Valachil, Maniyampara
A.*Burmannia pusilla* and *Eragrostis indica on* RC,B.*Impatiens acaulis,* C.*Exacum pedunculatum,* D.*Hedyotis kurzii*,E. *Isachne veldkampii,* F. *Drosera indica.*

Plate 25: Initial stages of seasonal succession

A. *Rotala malampuzhensis* & *Murdannia semepteris*,

B.*Eriocaulon richardianum* & *Utricularia purpurascens*,C.*Utricularia reticulata*,

D.*Eragrostis indica*,.E.*Rotala's* & *Eriocaulon*'s,F.Poaceae & Cyperaceae members.

Plate 26: (A-F).Seasonal succession stages in a temporary pond

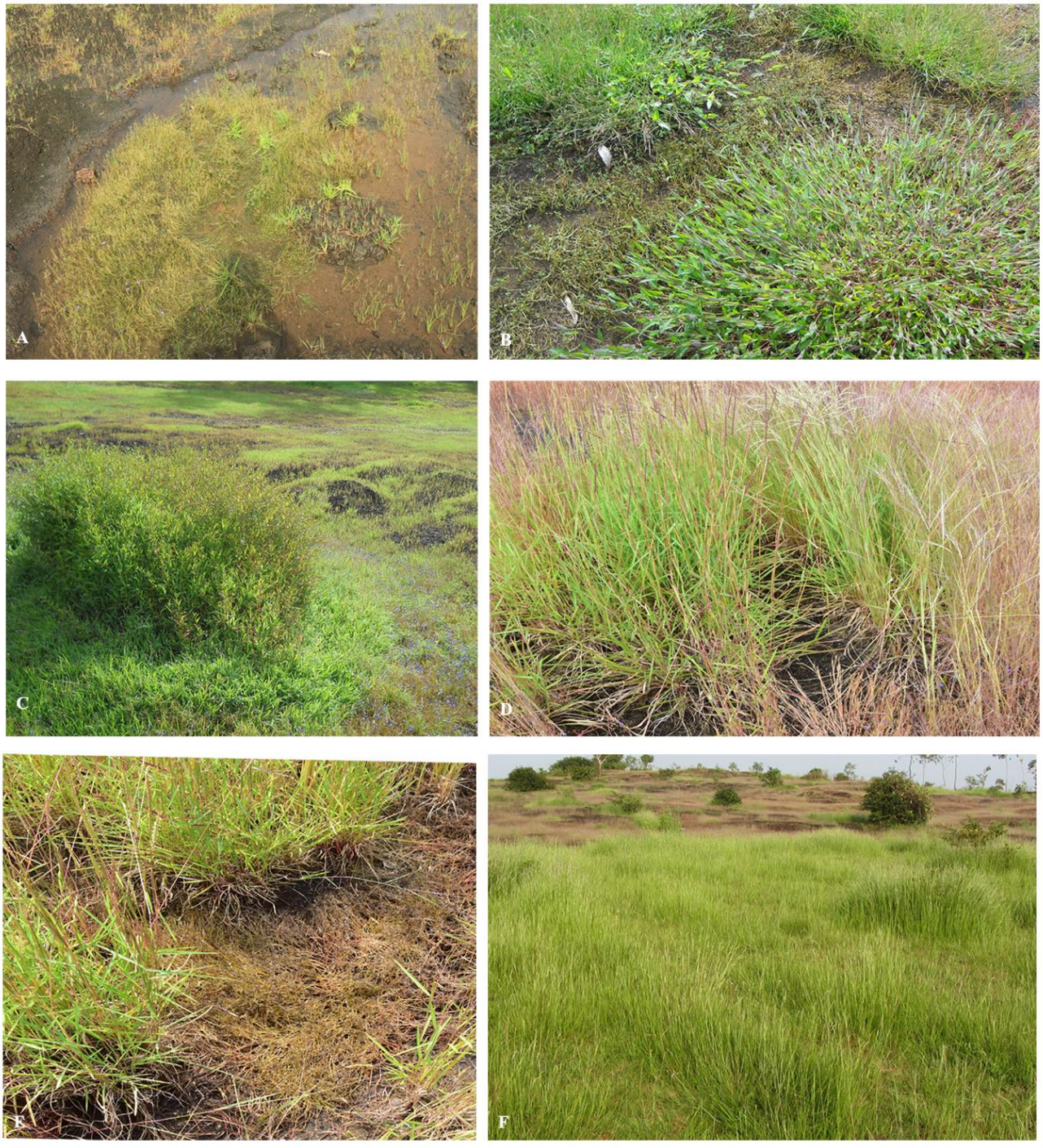

Plate 27: Study Location : Bhatkal Plateau
A-C. plateau responses during post monsoon stage and dry summer

Plate.28: Study location: Konaje Plateau

A-C. Temporary water pool during successive stages of monsoon

Plate 29: Study location:Konaje

Temporary water pool showing transition from monsoon phase to dry phase

Plate:30. Study Location Konaje during dry phase

Plate 31: Study Location: Posadi Gumpe

A&B. Plateau during dry Phase, C.& D. *Lepidagathis prostrata and Justicia procumbens in rock crevices*, E. Lichen sp on the surface of rock. F. *Reissantia malabarica*

Plate 32: Study locations: Konaje and Kotappara
A-F Different micro habitats during dry season

Plate 33: Study Location : Seethangoli
A&B. Plateau during dry phase

Plate 34: Study Location: Ananthapura, Madayipara

A.*Lepidagathis clavata*, B.*Lepidagathis prostrata,* C.Ant visting the flower

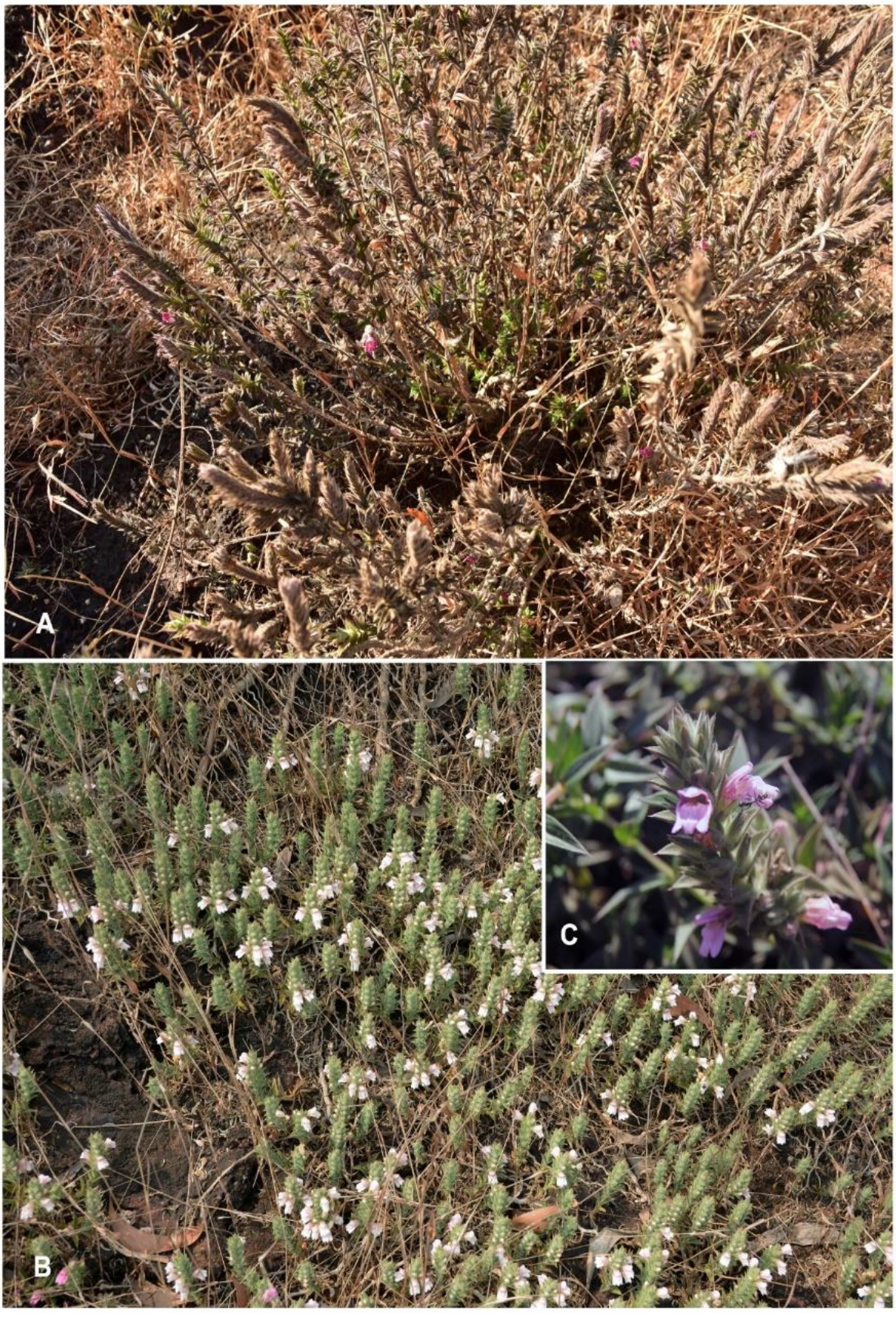

Plate 35 Study Location : Koila Plateau

A.*Leucas linifolia*,B. *Exacum lawii*,C.*Solena amplexicaulis*,D. *Rotheca serrata*, E.*Gloriosa superba*, F.*Aristolochia indica*

Plate 36: A.*Diploclisia gaucascense,*B.*Curculigo orchiodes,*C.*Hybanthus enneaspermus* D.*Holigarna ferruginea,*E.*Naregamia alata,* F.*Buchnania lanzan*

Plate 37: Study Location: Konaje and Bhatkal
A-C: Plant-pollinator interaction

Plate 38: Study Location: Konaje plateau

A. *Crotalaria quinquifolia* habitat

B. Spongy stem, C.T.S of stem

Plate 39 Cultural significance of low altitude plateau regions during monsoon.

Photo Credit : Vijaya Kallakatta

Plate 40: Pollination studies in *Blyxa mangalensis*

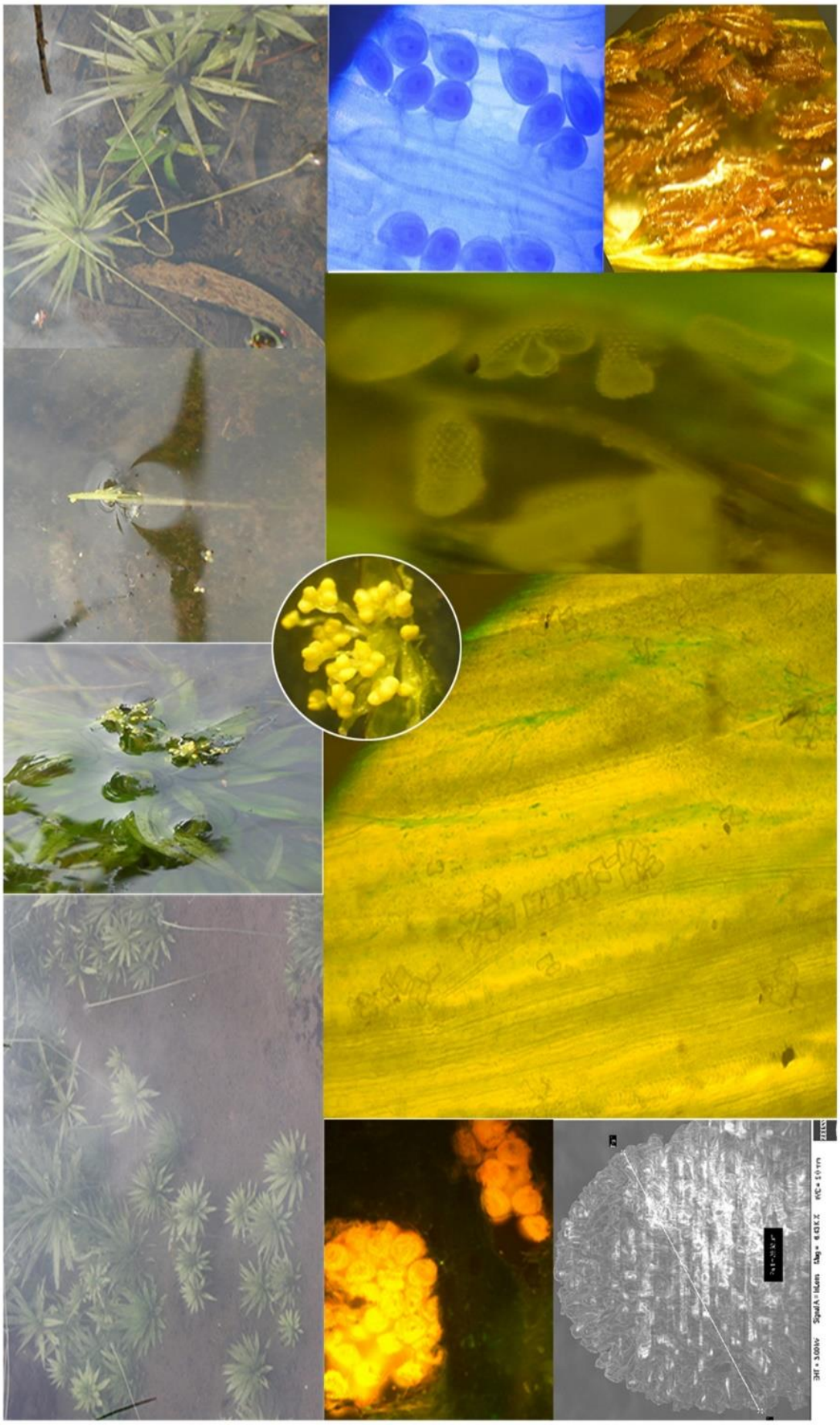

Plate 41: Study location : Madaipara
A. Temporary water pool. B.Edge of the pond

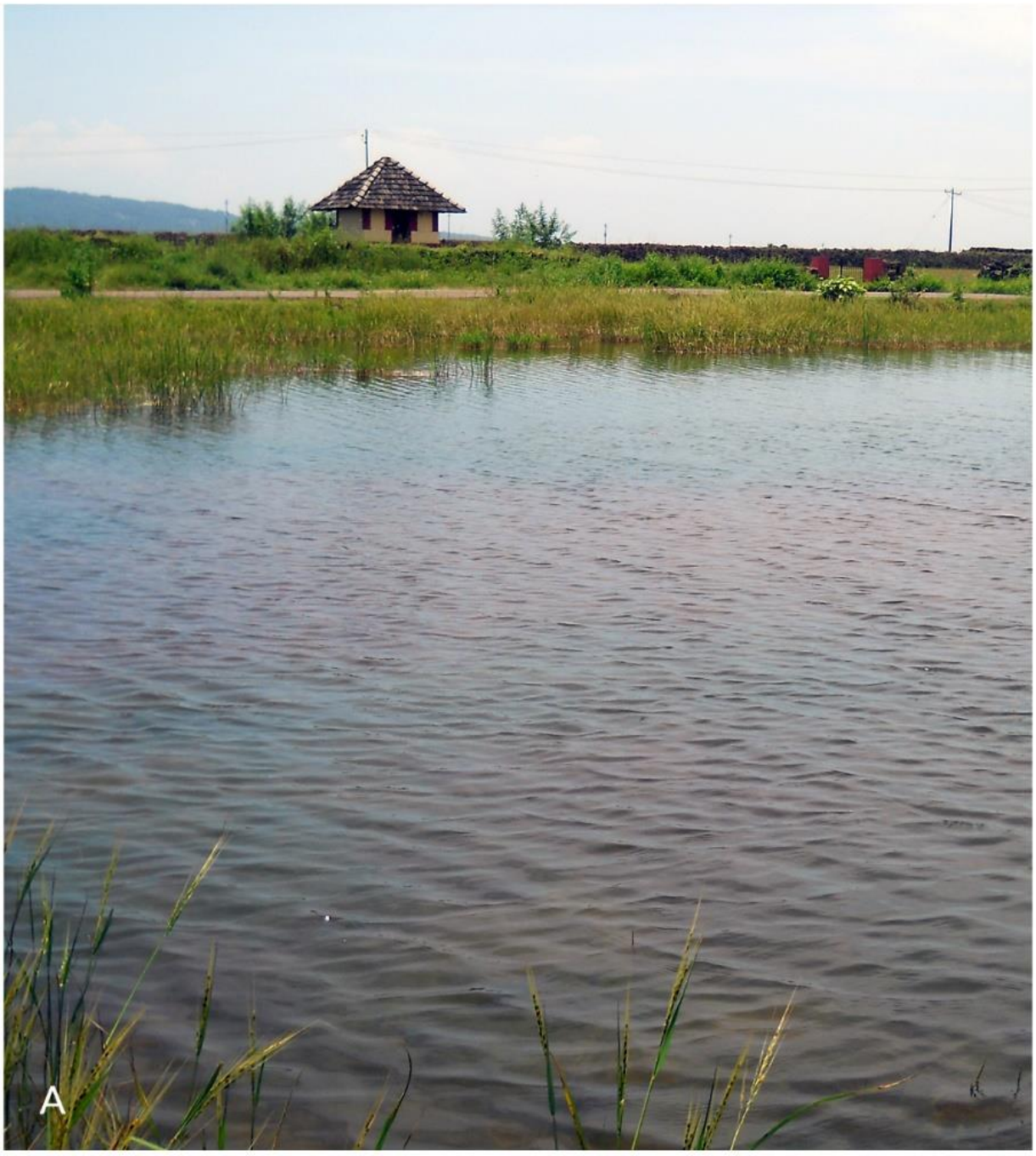

Plate 42: Study location: Posadi gumpe and Perla

Different types of Surangas

Photo credit: News Minute

Plate 43 Study Location: Puthige and Manityampara
A. Anadi Palla B.Kajoor Palla

Photo Credit: Akshatha K

Photo Credit: Raju Kidoor

Plate 44: Major threats to low altitude grasslands

A-D. grasslands burnt due to fire, E.*Acacia* plantation, F.Invasive weed *Spigelia anthelmia*

Plate 45. Study Location: Mudipu & Konaje

A&B. Major threats to the low altitude grassland plateau (Quarrying and construction)

Plate. 46: Threat to the low elevation grassland plateaus

A.Constrution of buildings ,B. construction of roads and pathways., C. Spending leisure activities, driving classes on the plain plateaus.

Plate 47: Researcher collecting specimen from different locations